EXD.

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ROLAND V. NORRIS, D.Sc., F.I.C.

Director, Tea Research Institute.

THE TEA RESEARCH INSTITUTE,

St. Coombs, Talawakelle.

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TEA RESEARCH INSTITUTE, ST. COOMBS.

*Photo by C. A. Loos*

General View of Laboratory.

TEA RESEARCH INSTITUTE, ST. COOMBS.

*Photo by C. A. Loos*

St. Coombs Factory.

# EDITORIAL.

## T. R. I. CONFERENCE.

The Institute's new laboratories were formally opened by His Excellency the Officer Administering the Government on Thursday, February 25th, and the morning was spent by His Excellency and the other visitors to the Conference in an inspection of the various sections, in which demonstrations were given accompanied by short explanatory lectures by the members of the staff.

In the afternoon, the Second Conference of the T. R. I. was initiated by His Excellency and this continued on Friday morning, Friday afternoon being left free for an inspection of the Factory. A full report of the proceedings will be found in the present number. The Conference was attended by more than two-hundred planters and the discussions, which covered a wide field, were of the greatest value in elucidating different points of view and suggesting additional lines of investigation.

## PRUNING EXPERIMENTS.

Arrangements are now in hand for two series of pruning experiments. One series will be carried out at St. Coombs and will embrace a study of different *types* of pruning and of the influence of different *times* of pruning. The second series will be done at the Experimental Station, Peradeniya, with the co-operation of the Department of Agriculture. At Peradeniya also different types of pruning will be studied, but the area of land available will not permit of the time factor being investigated there. Full details of the above experiments will shortly be announced, and it is hoped to extend the series by a similar set of experiments in the low-country at a later date.

## SOIL EROSION.

The Report of the Soil Erosion Committee has now been issued and contains matter of the highest interest and value. As was not unexpected, the Committee has emphasised in the strongest possible way its considered opinion that the first line of defence against erosion must consist in a wide use of cover crops, with improved systems of drainage as a secondary protection. The Report should be closely studied by every planter and we think few can fail to be convinced by the facts set forth therein. A short review of the salient features will be found in the present number.

The recommendations of the Committee are at present receiving the attention of the Institute's Experimental Committee. While details of future work on this subject cannot yet be given, soil erosion and its connected problems will constitute one of the main lines of investigation in the Agricultural Section.

# TEA FERMENTATION—PART V.

D. I. EVANS.

## THE MICRO-ORGANIC THEORY OF TEA FERMENTATION.

Bernard (*Meded. van het Proefstation voor Thee*, 1909) ascribes the first suggestion of the micro-organic theory of tea fermentation in 1891 to Kozai and then states that Wahgel looked upon the production of flavour as being due to special bacteria (1903). At this time, however, the investigators referred to in the previous article were busy investigating the enzymes of the tea leaf and the general opinion inclined to the belief that tea fermentation was due to an enzyme or ferment, though this theory remained unproved. On the other hand the idea that micro-organisms were concerned had not been disproved, although this appeared to be unlikely. The chief objections to the micro-organic theory were the following:—

(a) Fermentation takes place so quickly that it was suggested micro-organisms could not possibly take part in the process, in spite of the fact that they could be demonstrated as present on the leaf. The protagonists of the micro-organic theory, however, very rightly pointed out that the yeasts and bacteria in the fresh leaf could multiply very rapidly during the period of withering, and thus be present on the withered leaf in sufficient amount to effect the changes observed. It is to be regretted, however, that although the earlier workers on the yeasts and bacteria of tea leaf all state that these increase during withering and fermentation, they failed to produce any data in support of this. Tunstall (*Qart. Jour. I. T. A.*, 1923, IV.) says "there was a steady increase of the number of yeast cells present as the manufacture proceeded until the maximum was reached when fermentation was completed." There are however no data given in support of this and it is surprising, if the yeasts were responsible for fermentation, that this steady increase did not show some marked acceleration at the moment the leaf was crushed and the yeast enabled to utilise its proper medium. This question had already been carefully investigated by Bosscha and Brzeskowsky (*Med. v. h. Proefst. v. Thee*, 1916, XLVII) but their figures, which will be referred to later, do not show any great increase in the number of yeast colonies on the leaf during withering.

(b) The second objection to the micro-organic theory of tea fermentation was the claim that rolled leaf could ferment in the presence of chloroform vapour, which prevents the action of any micro-organisms. Although the weight of evidence appears to confirm this, there is a slight doubt, however, whether anybody has ever produced properly fermented tea in the presence of chloroform vapour or not.

In spite of these objections it was maintained that certain phenomena observed in practice could only be explained on the basis of the presence of active micro-organisms. Typical instances of these peculiarities are given by Bernard (*ibid*). Thus, it was stated that a slow fermenting leaf could be made to ferment quicker by inoculation with a small quantity of the quicker fermenting leaf. Several instances of this are referred to, such as the acceleration of

the fermentation at Tanara and Wanasoea as a result of mixing the slow fermenting leaf of these factories with leaf from Malabar where the fermentation was very rapid. After describing these particular instances Bernard describes his own experiments conducted to study the micro-organisms which could be separated from tea juice. He succeeded in isolating a yeast-like organism which appeared to be always present on the tea leaf, and which did not at least exert an unfavourable action on the fermenting tea, even if it were not responsible for the fermentation. At the same time it was found that certain bacteria were associated with the leaf and that, if these were allowed to multiply to any extent, then the leaf developed bad odours and became sticky. Finally, Bernard pointed out that the work in the factory must be carried out under as clean conditions as possible, and suggested further experiments which should be carried out in this particular field.

Deuss and Brzeskowsky (*Med. v.h. Proef. v. Thee*, 1916, XLV) report their experiments on tea fermentation at Kertasari, where the fermentation was very slow. The nature of these experiments can be seen from the way they were conducted:—

(a) Kertasari leaf was fermented at Kertasari and Malabar.
(b) Malabar leaf was fermented at Kertasari and Malabar.
(c) Kertasari leaf was mixed with Malabar leaf for rolling.
(d) Malabar leaf was mixed with Kertasari leaf for rolling.
(e) Kertasari fresh leaf was manufactured at Malabar.
(f) Malabar fresh leaf was manufactured at Kertasari.

These experiments were carefully watched by several people who are reported to be of the same opinion as to the results obtained. The experiments showed that mixing quickly fermenting leaf from Malabar with slow fermenting leaf from Kertasari had no effect on the rate of fermentation, whether conducted at Kertasari or Malabar. It was found, however, that the temperature of the surroundings was a very important factor in deciding the rate of the fermentation, and that the temperature was too low at Kertasari. This could be improved by fermenting the tea near the dryer, and the period of fermentation was reduced in this way from 6 hours to 3 hours. This fact eventually led Deuss to conduct the investigations on the effects of temperature on fermentation already described in a previous article. These particular experiments, carried out at Kertasari and Malabar, appear to have been subjected to a good deal of criticism by the advocates of the micro-organic theory of tea fermentation, but Deuss' later experiments concerning temperature of fermentation supplied more evidence in support of the contention that temperature differences were sufficient to account for the differences observed in the period of fermentation in the two estates.

Bosscha and Brzeskowsky (*Med. v.h. Proef. v. Thee*, 1916, No. XLVII) considered that the previous experiments did not decide definitely whether tea fermentation was due to an oxidase or to micro-organisms and that further work was necessary, since it was very important to determine whether aseptic condition should be maintained in manufacture or not. Further, they pointed out the necessity for determining the proper temperature, aeration, and thickness of spreading of the leaf that is necessary when experiments are being carried out if these variable factors are to be eliminated. The best material for experimentation would be plants grown under sterile conditions, but they considered this too laborious and expensive, and they thus turned their attention to ways and means of sterilising the leaf without changing its nature.

The first thing these authors did was to determine what organisms could be found in association with the tea leaf, and this necessitated a preliminary investigation of the most suitable media for the culture of the organisms. They describe the various media used and show that organic nitrogen in the form of peptones is necessary for their proper growth. A full description is given of their method of preparing the cultures from fresh leaf or leaf sap, followed by an account of the organisms isolated.

They found a variety of fungi, yeasts, and bacteria on the tea leaf, as reported by previous workers, but complain of the difficulty of working as a result of the mixtures which always developed on their plates. However the micro-organisms could be divided into 3 primary groups (1) Fungi (2) Yeasts and (3) Bacteria.

(1) *Fungi.*—The fungi, represented by different types such as Aspergillus, Penicillium and Mucor were found in profusion. When grown on a sterilised tea decoction they invariably produced a dark-brown colouration and a disagreeable smell. They also decomposed tannin solutions with the production of gallic acid, but if a tea decoction was used instead of a tannin solution then gallic acid was not produced, which indicates a difference in constitution between ordinary tannin and tea tannin Dematium which lies between the fungi and the yeasts, was also found to be present, but this growth was not very prolific on a tea decoction.

(2) *Yeasts.*—By using a meat-agar culture they were able to isolate the yeasts almost free of bacteria, and found the same yeasts as had been previously described by Staub and Bernard. The number of yeast colonies did not show any great increase during withering, although they increased sharply during fermentation, as will be seen from the data they give:—

| | | |
|---|---|---|
| Fresh leaf | ... | 10-20 colonies. |
| Withered leaf | ... | 20-30 ,, |
| Fermented leaf | ... | 70-80 ,, |
| Pekoe after picking | ... | 0- 5 ,, |

Hot tea from the driers seemed to be free of yeasts, but picked up a few in the process of handling. They studied the action of these yeasts on starch paste and found that they contained a starch decomposing enzyme, and that the yeasts produced a brown colouration of a tea decoction, but this was not accompanied by a disagreeable odour as in the case of the fungi.

(3) *Bacteria*—Several kinds of bacteria were found and these are described. Without entering into a description of these organisms, the salient point to be noted from their work is that the bacteria also turned a green decoction of tea to a dark-brown colour, with the production of an objectionable smell resembling overfermented tea. The investigators inclined to the belief that the bacteria never benefit the fermentation but on the other hand corrupt the tea as a result of their activity. In this connection they also prepared enzymes from the micro-organisms isolated but none of these exhibited an oxidase or peroxidase reaction, so that, even if the micro-organisms do play a part in fermentation, it is not as the result of the formation of a peroxidase.

*Sterilisation of the Tea Leaf.*—Tea leaves were sterilised by being dipped in boiling water and then left hanging in steam. The leaf was rendered germ free by this process, but the nature of the leaf was so changed that no fermentation could take place. A brown colouration of the leaf could be produced by inoculation with fungi and yeasts or by the addition of oxidants like permanganate or chromic acid, but it was not the colour of properly fermented leaf and in no case was the tea aroma produced. Sterilisation by means of various chemicals was then investigated and it was found that the addition of formalin altered the composition of the leaf so that fermentation was prevented. Chloroform did not seem to affect the fermentation and no difference could be detected in chloroform-treated tea from non-treated tea. Hydrogen peroxide and corrosive sublimate in dilute solutions did not affect the normal fermentation but in greater concentrations this fermentation was stopped altogether. Teas prepared after treatment with sublimate of mercury or peroxide gave identical infusions and liquors as untreated tea, but this statement must be accepted with caution for it is modified by saying that the peroxide tea was not quite so fine and had a somewhat fishy taste.

When the authors were satisfied that good tea could be made from leaf treated with dilute peroxide or corrosive sublimate solutions they set out to discover what effect this concentration of antiseptic had on the micro-organisms. It was found that treatment of the leaf in this way rendered it free of any micro-organisms and this method was adopted to sterilise the leaf used in their experiments.

These experiments were followed by a series of experiments to determine the temperature necessary for a normal fermentation. They failed to produce any fermentation in leaf maintained in an autoclave at 100°C (212°F) and then tried at 50°C (122°F) but no fermentation could be detected. On testing out the leaf at different temperature levels varying by 1°C they experienced the first normal fermentation at 43-43·5°C (109-110·3°F). They regarded this temperature as a critical temperature for tea fermentation, as any slight increase above this figure gave a yellow

liquor and green infusion. Some of the bacteria were found to develop rapidly at 45°C (113°F) and a good growth of all the micro-organisms was obtained in tea treated at these high temperatures. The interruption of the fermentation at this temperature is not therefore in keeping with the idea that it is due to the presence of these organisms, but agrees with the conception that the enzyme is inactivated at this particular temperature. Although they considered tea fermented at 43°C (109·4°F) was normally fermented, it was yet inferior in the quality of the liquor and aroma to that fermented at lower temperatures.

The course of the fermentation was followed in their subsequent investigations by means of temperature determinations of the fermenting leaf, since they were able to satisfy themselves that the course of the fermentation could be followed in this way, and that the cut leaf used in their experiments did not differ in its conduct from normally crushed leaf. 800 gms. of crushed leaf was fermented in a specially constructed box to minimise the loss of heat from the fermenting leaf, and the following observations were made:—

(1) Leaf temperature.
(2) Yeast and bacteria counts.
(3) Samples were dried and tasted for fermentation.

The temperature of the leaf went up at first to 29°C (84·2°F) and at this point plenty of yeasts and bacteria could be determined in the leaf material, but the yeasts predominated. The best tea was produced from the sample dried at this point in the temperature curve, the time taken to reach this temperature being 3-4 hours. The temperature of the leaf dropped after this, and later again increased to 34-35°C (93-95°F). When the temperature dropped and then increased a change took place in the micro-organisms isolated, since the yeasts appeared to diminish and the bacteria increased rapidly at this stage. Eventually the surface of the leaf became covered with a thick matt of fungi. The aroma of the fermented and dried leaf diminished as the temperature receded from the first maximum of 29°C (84·2°F) but the colour of the liquor and infusion were still satisfactory. When the temperature started to increase the second time, and the moulds developed, the liquors became black and the infusions a dark-brown, while the objectionable smell of overfermented tea developed.

By studying the leaf in this way they came to the conclusion that the presence of the yeasts did not interfere with the proper development of aroma, colour of the liquor, or infusion, and that tea fermented in their presence tasted normal.

The presence of bacteria produced the smell of overfermented tea, dark-brown liquors and infusion, and gave the tea a tarry taste.

Development of moulds produced a mouldy smell, light to yellow liquors, black infusions and a decidedly objectionable taste.

These experiments were then carried out with sterilised leaf, and although an initial rise in the temperature of the leaf occurred, as in the case of the non-sterilised leaf, showing that normal fermentation was proceeding in the absence of micro-organisms, the second rise in temperature could not be observed for several days or until fresh moulds entered the leaf and developed. Under certain conditions it was found possible to maintain the leaf sterile to the end of the experiment, and thus eliminate the second rise of temperature entirely. At the same time, the quality of the samples of tea prepared from the leaf sterilised by means of chloroform and mercury sublimate was equal to the ordinary make. By sterilising the leaf before it was fermented it was claimed that the fermented leaf could be kept in this condition for several days without deterioration, whereas the normal tea was overfermented at the end of the first day. A normal fermentation of tea thus appears to be possible under conditions which exclude the possibility of any micro-organic action and, when this sterile leaf is fermented, the ordinary signs of overfermentation is not produced in the leaf even after prolonged fermentation.

The next point to be investigated was the development of carbon dioxide by the fermenting leaf. Similar curves were traced for the rate of development of carbon dioxide as for the rise in temperature of the leaf. The carbon dioxide production reached a maximum soon after the start of the experiment, and then fell in the same way as the temperature of the leaf did. Carbon dioxide was also produced by sterilised leaf, but after the point of maximum production was reached the amount of carbon dioxide produced diminished and eventually attained a point where none was produced at all. When infection by means of spores took place the production of carbon dioxide again occurred very rapidly. Fermentation of tea thus results in the production of carbon dioxide but this carbon dioxide is not the result of the growth of micro-organisms since it is developed during the fermentation of completely sterilised leaf. When the fermentation is completed the development of carbon dioxide also ceases unless the tea becomes infected with moulds when it develops an overfermented taste and carbon dioxide production again becomes rapid.

As a result of these experiments it was concluded that the process of tea fermentation was independent of the growth of micro-organisms on the leaf, and that cleanliness above all things should be observed during the manufacture of tea. Further, tea fermentation is accompanied by the production of heat and the development

of carbon dioxide, but these phenomena occur in the same way in the absence of micro-organisms. Tea fermentation must therefore depend on the action of a ferment in the leaf or on an oxidation of the components of the tea by the oxygen of the air, but it was not possible to decide between these two possibilities as a result of the investigations just described.

Athough some of the methods adopted in these investigations may be open to criticism, it must be admitted that the array of evidence collected by observations on the number of organisms present, the temperature changes in fermenting leaf, the production of carbon dioxide, and the quality of made tea, is all against the idea that bacteria or fungi play any beneficial part in tea fermentation. On the contrary, they invariably corrupt the tea, but this charge could not be brought against the yeasts present, although there was nothing to show that these were in any way necessary for a satisfactory fermentation.

Tunstall (*Q. J. I. T. A.*, 1923, **4**) published a short note on the work done by him concerning the micro-organisms associated with tea fermentation. He decided to disregard the conclusions arrived at in Java, although it is difficult to understand his reasons for doing this. Tunstall reports that complete sterilisation of the leaf with chemicals always rendered the leaf incapable of further fermentation, and his experiments were carried out with unsterilised leaf. Startling results are described by the author who claims to have reproduced the aroma characteristic of fermenting leaf belonging to one particular factory in another factory by inoculation with the yeast produced in the first factory. He also claimed that it was possible to change the flavour of tea by inoculation with the proper yeast, and that the yeasts present when the best quality tea is made are more active than those found on the leaf at other times of the year. It is pointed out, however, that the organisms found on the fermenting floors, rollers, etc., are usually undesirable, and that some of the bacteria isolated gave characteristic taints to tea. One of these taints resembled the effect produced by overfiring.

It is impossible to judge the value of this contribution since no data as to the technique of the methods employed for the investigations are given and the actual experiments carried out are not described. The work was done at least seven years ago but no further details have been published and there does not appear to be any great development in the production of special yeasts for the inoculation of tea in North India. In this connection it may be pointed out that Benton (*Q. J. I. T. A.*, 1930, **4**), says that "The main fermentation process is controlled by enzymes of the leaf, and is independent of outside biological influences."

In conclusion, it may be said that yeasts, moulds and bacteria do exist on the tea leaf and that these may multiply during the manufacture of tea. It is also possible to produce fermentation in completely sterilised leaf so that the micro-organisms are not essential for the chemical change. It is not very certain, however, whether this fermentation is a normal one or not. On the other hand, it is clear that a rapid development of the micro-organisms can take place at higher temperatures than allow of any fermentation of the leaf at all. Although no ill-effect could be ascribed to the presence of yeasts, any development of moulds and bacteria resulted in dark or yellow liquors, accompanied by characteristic smells such as overfermented tea, and it can be definitely stated that fermentation conditions which cause the development of moulds or bacteria will result in poor teas. It is, therefore, essential to have clean conditions for fermentation and rolling, and fermenting rooms should be kept sweet and fresh if taints are to be avoided. The remarkable point in the researches described is the discovery that tea leaf fermented after sterilisation could be kept for several days without showing any sign of overfermentation, even at the end of the period.

This is a very important discovery if it can be definitely proved that a normal tea can be produced with sterilised leaf.

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## REPORT ON THE COMMITTEE ON SOIL EROSION.

### (REVIEW)

The Committee on Soil Erosion appointed in June, 1929 has issued its Report as *Sessional Paper No. III, 1931*. It will be known that the personnel of that Committee included representatives from the planting community and from the Government Departments responsible for Agriculture, Survey, Irrigation and Forestry, together with an administrative member from the Civil Service, so that the Committee was able to interpret its terms of reference in the widest possible manner. The result is a report of great detail and interest which puts before the public a mass of information which is both instructive and readable. The Committee is to be congratulated on having infused the dry bones of a sessional paper with life and vigour and we therefore wish that a more permanent and attractive format could have been given to a document which we believe will be widely read and used.

The programme of the Committee included not only an extremely comprehensive collection of evidence from over one hundred and fifty representative witnesses, but also personal visits to localities in which soil erosion was specially serious, and in which

a variety of protective measures were in operation. There is evidence that the latter aspect of the work was prominently in the Committee's mind when the drafting of the report was undertaken and it is no criticism of the report, but rather an indication of the Committee's own keenness of observation, to say that the report bears largely on the Committee's own investigations.

The plan of the report is to give first a survey of the problem of soil erosion with special attention to Ceylon, and then to pass on to the field evidence. This is divided into "Internal Evidence," *i.e.*, that afforded by eroded sites, and "External Evidence" which is afforded by damage due to flooding, silting, and the destruction of works resulting from the rapid delivery of water from eroded sites, in some cases in localities far distant from the original source of the trouble.

The field evidence naturally leads on to the section in which the Committee's considered views are propounded. The final section is devoted to the general recommendations that the Committee feels can usefully be made. The recommendations are unanimous. Appendices are devoted to documents quoted in the text, and to illustrative maps, diagrams and photographs.

The introductory chapter is one of the most interesting in the report, for the documents quoted (mainly previous reports on the problem of Soil Erosion) show that most of the views and recommendations of the Committee have been published and in the hands of Government for some considerable time. In 1905 for instance, a Soil Denudation Committee on the state of affairs in the Kelani Valley stated that the prime cause of trouble was faulty opening of land, a point which the present Committee strongly stresses later. In 1909 Mr. W. L. Strange, who was deputed by the Government of India to report on Irrigation in Ceylon, made recommendations which to quote the present report, "represent to a considerable degree of accuracy the views of the present Committee." Again, in 1921, Mr. P. M. Lushington of the Indian Forest Service reported on the harmful results of ill-advised alienation and, together with the Surveyor-General and Director of Irrigation, made definite recommendations. Both these reports stressed the fact that *run-off* was the prime danger, that *low cover* was the only adequate means of prevention and that *clean weeding* should be discouraged. In 1923, Mr. C. E. Corea, in a rider to a report of the Forest Committee, urged that on new clearings cover crops, contour drains, hedges and terracing should be compulsory.

Whilst therefore insisting that the main recommendations of the report can be traced to earlier documents it would be churlish not to recognise that the present Committee has amassed a much greater

bulk of evidence for these methods than has ever before been tabled, and that the recommendations now have the authority not only of the specialist but of a considerable body of practical agriculturists.

Details of the views of the Committee and their reasons for espousing them cannot be given in a short review and the reader is referred to the report for their elaboration, but the main points centre round a number of clear cut views. New clearings should be opened with a full complement of anti-erosion devices from the very start: cover crops should be grown, drains designed to hold up water rather than conduct it away should be constructed, and patna should not be burned.

Mature tea should be converted as soon as possible into sites on which ground cover, terraces, paspalum strips, and hedges all combine to increase soil porosity and diminish surface run-off. There is a "*Delenda est Carthago*" motif running through the whole report to the effect that clean weeding must go.

The recommendations of the Committee are concerned with the means for translating the views explained in the report into actual practice. Legislation generally is ruled out as impracticable, we think rightly so, for it is no use legislating in advance of public opinion. Nevertheless we should not have been surprised if some restraint had been suggested in the methods of clearing new ground. The suggestion has been made to amend the Irrigation Ordinance No. 45 of 1917 so as to compel the responsible parties to prevent the risk of causing external damage to paddy fields. A similar protection to roads and other public works is not so definitely recommended. It appears to us that no greater hardship would be involved in stipulating enlightened drainage systems than will be caused by enforcing neutral strips and drains below sites where internal damage may be likely to provoke external damage too, and both parties would be the gainers ultimately. The Committte originally contemplated legislative recommendations but abandoned them, without doubt for very carefully considered reasons.

The main emphasis is therefore placed on education and research with a time-limit of five to seven years, and the question is whether anything effective can be done in so short a period, and if so, what.

It has been pointed out earlier that the main recommendations have been common property for some ten to twenty years, yet the progress has been slow. The present report should give an impetus to the educational campaign; but we are of the opinion that very careful and hard work will have to be done to make the sort of progress required in five years. A soil erosion officer is suggested, and this seems a move in the right direction. His usefulness will depend on two factors, (1) the readiness of the planting community to make use

of him and (2) the adequacy of the "artillery" he can bring to bear on the problem. In our opinion his mainstay must be the result of research and more research. Private individuals have led the way and have given valuable indications of how to deal with soil erosion, but, in the nature of things, it has not been possible to make exact comparisons of the efficacy of various systems. As the Committee points out, the fundamental characteristics of the erosion problem have never been touched. What is true of Ceylon holds elsewhere. The Imperial Bureau of Soil Science *Technical Communication No. 5*, reviewed in this journal in February 1930, shows, that "little experimental work has been done" (to quote the Committee's own words). The one disappointment of an otherwise able report is that, after pinning its faith so ardently to education and experiment, it has given so little indication of the scope and machinery to deal with its main recommendation. We should have liked to see more definite recommendations for co-operative work as a basis for discussion. The Committee was evidently loth to recommend increase of staff, but it must have been aware that the catalogue of suggested problems would entail whole time work for more than one officer exclusive of the propagandist appointment tentatively suggested. The direction of research on the scale needed and evidently contemplated, is an unfair and unfruitful burden to thrust on a departmental director already fully occupied. Moreover to complete the programme, those already working on the fringe of the subject would have to make that work the primary call on their time. It may not be possible to sway the balance of soil research thus thoroughly onto the erosional aspect, but this is the logical outcome of the Committee's hopes, and to leave the matter in doubt is to court disappointment all round. The normal development of soil research in the various research institutes, as at present constituted, will not produce the body of experimental evidence required if the five-year plan is to produce any real advance in the public opinion of agriculturists. The public will read the report and profit by it, but the interest must be sustained in the intervening five years by the production of new facts and new figures. The soil erosion report will form an admirable text, but it must not be allowed to form the whole of the discourse.

T. EDEN.

# MODERN TEA FACTORIES IN JAVA.

## (REVIEW)

The January 1931 number of *The Tea and Coffee Trade Journal* contains a most interesting illustrated article on modern tea factories in Java and Sumatra. Some of the ideas incorporated in these factories are unique and I think they should be brought to the notice of our readers.

It appears that the Government Cinchona and Tea Undertaking (Kina en Thee Underneming) decided to open a model tea plantation on its 1250-acre estate in Pangelengan and to build an up-to-date tea factory. The clearing of the forest was started in 1926, and planting was nearly finished in 1930. The building operations started in December 1929 and the factory was officially opened in July 1930. This building is built entirely of iron, concrete, and glass, the only wood in the factory being that of the floors of the withering lofts. The equipment includes open top, double action, Hollandia Rollers advocated by the Experiment Station at Buitenzorg, and transport of fresh and fermented leaf is carried out by means of the Tourtellier monorail system described in this Journal (*T. Q.*, 1929, **4**).

The banks of tats in the withering lofts are isolated from the longitudinal passage by means of a partition and the fermenting room has double concerete walls for insulating purposes. The fermenting leaf from the roll breakers is spread out on a tier of trays which are transported with their load of spread leaf into the fermenting room by means of the monorail track. During the fermentation these tiers of trays are suspended from the monorail track so as to allow a free circulation of air around the fermenting leaf. Presumably, the whole stack of tiers and leaf is then transported as such to the dryers without handling the leaf, when the fermentation is complete. The fermenting room is humidified and maintained at a constant temperature of 23°C. (73·7°F) by means of a Sulzer spray and an electric hot air installation.

Empire dryers and Java sorters are installed, and the tea is graded into B.O.P., O.P., B.P., Pekoe, Fannings and Dust. The atmosphere of the sorting room is kept clean by means of dust fans placed in the outside walls. This factory has been designed and constructed by H. V. Machinefabriek Bratt, together with the H. V. Technisch Bureau Sanders Birnie, the electric installation being supplied by Siemens. When the estate is in full production the output will be about 1,700,000 pounds of tea per annum.

It appears that another factory is to be built in Sumatra to deal with 2,000,000 pounds of tea, and equipped with modern appliances and mechanical transport. It is of interest to note that the designs for this factory and those on Poerbasari and Gedeh were drawn up by the Advisory Bureau of Bandoeng in consultation with the Tea Experiment Station Staff at Buitenzorg.

D. I. EVANS.

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# THE SECOND CONFERENCE OF THE TEA RESEARCH INSTITUTE.

The Second Conference of the Tea Research Institute was held at St. Coombs on Thursday, and Friday, February 25th and 26th and was made the occasion for the formal opening of the new laboratories by His Excellency the Officer Administering the Government.

## PROCEEDINGS OF THE FIRST DAY.

The Acting Governor, attended by Capt. Littleton-Geach, arrived at the Institute at 10 o'clock and was received by Mr. R. G. Coombe, Chairman of the Board, and Dr. Roland V. Norris, Director of the Institute. The members of the Board and the Scientific Staff were presented to His Excellency, who thereafter formally declared open the new laboratories.

Then followed a tour of the laboratories, attended with demonstrations by members of the staff, bringing the morning programme to a close.

After lunch, the Conference assembled in the factory when the chair was taken by His Excellency.

## ADDRESS BY MR. R. G. COOMBE, CHAIRMAN OF THE BOARD.

Before Your Excellency does us the honour of declaring this Conference open, I desire on behalf of the Tea Research Institute to say how very pleased and honoured we are to see you here today and to express our appreciation to you for the ceremony you performed this morning in officially declaring our Research Station open. I trust, Sir, that what you have already seen and are, we hope, to see tomorrow will satisfy you that the loan made by Government some years ago has not been misspent.

I also desire to extend a hearty welcome to two visitors, who honour us by their presence today: I refer to Mr. Carpenter, the Senior Scientific Officer of the North India Tea Research Station at Tocklai, and Dr. Shaw from the South Indian Tea Association.

I take this long delayed opportunity to say to Mr. Carpenter how much we appreciated not only the hospitality which he and his staff extended to our deputation which visited North India in 1925, but more especially his full and willing co-operation in placing before them all details of his organization, thereby materially helping us to lay the foundations of this Institute.

I am sure I am voicing the opinion of everyone connected with the tea industry of Ceylon, when I say to both Mr. Carpenter and Dr. Shaw that Ceylon desires to co-operate with them, and the interests they represent, in every way possible, for the betterment and improvement of Tea Research in India and Ceylon.

Since I addressed you at our first Conference two years ago, we have made considerable progress in the large building programme which I gave details of then. First and foremost, the factory has been working since August, 1929, and has, I feel we may fairly claim, justified its existence. Besides the factory, the following buildings have been completed:—

The laboratories, which H. E. officially opened this morning.

5 bungalows for members of the Senior Scientific Staff and the Superintendent.

6 bungalows for the Junior Scientific Staff and sundry other houses for the accommodation of the teamaker, clerks, and other members of the subordinate staff.

The completion of these buildings enabled us to move from our temporary quarters in Nuwara Eliya, where we have been for just upon four years, to St. Coombs in December last. To complete the building programme necessary to accommodate the whole staff we have still to erect two more large and four more small bungalows. We hope that funds will permit the entire programme being finished by the end of 1933.

Due to the calls for labour in many other directions it has not been possible further to extend our acreage in tea. The Budget for the current year allows for 30 acres to be planted, and we hope a similar acreage in each succeeding year until the balance of the available acreage has been dealt with.

I cannot conclude this short review without expressing my personal appreciation, as Chairman of the Board, for the manner in which the whole Staff, both Research and Estate, have co-operated in the difficult times we have been through. To Dr. Norris especially and to Mr. Rogers, I would pay a special tribute for their untiring energy and assistance.

I am more than ever confident that our staff will justify its existence and the Tea Research Institute prove a boon to the tea industry of this Colony.

## HIS EXCELLENCY'S ADDRESS.

Mr. Coombe and gentlemen,—You have come here to listen to words of wisdom from experts and not to mere platitudes from a layman, so I will not keep you very long. But I should like to express my appreciation of the kindness of the Board in having asked me here today to open your new laboratories and to inaugurate the Second Conference of the Tea Research Institute. It is always a matter of interest to a layman like myself to find himself in a crowd of experts and to hear them discussing their problems. I feel that I assimilated a number of scraps of miscellaneous knowledge this morning, a good many of which have already leaked out and the remainder of which are already quite muddled up in my inside. But I am afraid that one of the results—not an intended result—is that I shall henceforward look upon a cup of tea with a certain amount of suspicion.

But, apart from the interest of this morning's proceedings, another reason why I am very glad to be here is that it gives me the opportunity of expressing on behalf of the Government my appreciation of the really important work which the Tea Research Institute is doing.

It is not necessary to tell you, who know much better than I do, what the tea industry has done for Ceylon in the past. I am not talking only of the money that it has put into the coffers of Government for them to spend, or as some have it, to misspend, but more chiefly of the tremendous prosperity it has brought to thousands and thousands of the inhabitants of this Island. And just now, gentlemen, when Ceylon is having its share—or as some of us may think, a good deal more of its proper share—of the hard times through which the world is passing, it is more than ever necessary that the tea industry of Ceylon should continue to play the part it has played in the past, and it is not going to play that part by merely standing still.

Again it is unnecessary for me to tell you that tea planting does not consist merely in sowing the seed and picking the leaves. Tea planting has developed into a highly scientific industry and if Ceylon is to hold its place among the tea-producing countries of the world—and I hope it will not only hold that place but improve its place amongst those countries—then it is necessary that it should keep abreast of the scientific developments of the industry—not merely that, I hope it will lead those developments. Well, gentlemen, it is only possible for the industry to do that if tea producers themselves will combine and co-operate, and the Institute which I am visiting today is a very magnificent instance of the proper sort of co-operation.

It is true that you have had a loan from Government, but the money which you collected and spent on this Institute is really your own money; you have imposed a voluntary Cess upon the exports of your produce and you yourselves are co-operating to finance a project which will certainly benefit yourselves but will also be a very great benefit to the Island at large.

I can only assure your Chairman that I am thoroughly satisfied that under his able direction the Board have made most excellent use of the loan which they had from Government.

I wish the utmost success in future to an enterprise which has now reached a very tangible form and which obviously contains in itself the seeds of the success which I wish it. Gentlemen, it gives me very great pleasure to declare this Conference open.

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## REVIEW OF THE INSTITUTE'S PROGRAMME.

### ROLAND V. NORRIS, DIRECTOR.

I should like to take this opportunity to endorse the remarks already made by the Chairman of the Board and to thank Your Excellency on behalf of the Staff of the Institute for so kindly coming here today to open our new laboratories and inaugurate the Second Conference of the Tea Research Institute. At the same time I would express our indebtedness to all of you gentlemen, who, by your presence here, are helping to make the Conference the success we all hope it will be.

The present occasion, Your Excellency, marks an important stage in the development of the Tea Research Institute, in so much as, after a long period of expectation and waiting, we are, at length, in possession of laboratories and equipment offering proper facilities for the work of the Scientific Staff. Most of those present have had an opportunity this morning of seeing the laboratories and I am sure you will agree with me that the tea industry of Ceylon now has at its disposal a Research Institute which should be the equal of any other Institute of its kind. Our thanks in this connection are due to our Architects, Messrs. Adams & Small and the Contractors, Messrs. the Colombo Commercial Company, who have done everything in their power to meet our requirements—and scientific officers, I believe, have the reputation of being rather difficult people to please. In this appreciation I must also include Mr. Meadows to whose plans the senior and junior staff bungalows have been constructed. Finally, before passing on to discuss the Institute's future activities, I cannot let this opportunity pass without acknowledging the work and loyal support of all my colleagues on the Institute Staff. Only those who

saw the temporary laboratories at Nuwara Eliya can appreciate the difficulties under which work was carried out there, but, in spite of the lack of anything but the most elementary facilities, results have been achieved and data accumulated which are of high value not only in their immediate application but also as a basis for work on a larger scale at St. Coombs.

The problems which await investigation are many and varied and the chief difficulty at present is, in fact, to decide what to omit from the immediate programme. It is, I think, admitted that the soundest principle in military strategy is to concentrate all possible forces on certain major operations offering the greatest opportunity for decisive results while, so far as possible, avoiding any wastage of one's resources on subsidiary actions which may be of only local importance. I think some such principle must guide us in drawing up our plan of campaign here. In application, such a course naturally has its disadvantages, particularly from the point of view of those defending the subsidiary positions, who may think they are not receiving adequate support from headquarters. I ask you gentlemen to bear these considerations in mind, if at any time I have to say to any of you that certain problems which may seem to you to demand attention cannot be immediately taken up without detriment to work of more general interest. But I do believe that the right policy for the Institute at present is to concentrate on some of the major problems before us and that the chief risk we have to avoid is the dissipation of our resources over too wide a field. The nature of some of these major problems will, I think, be clear to you if you refer to the programme of papers which will be read during the present Conference. In deciding how to approach such problems we may perhaps push the military analogy I have used, a little further. A frontal attack is frequently not the only or the best line of advance. The enemy must, if possible, be outflanked and driven from his position by a series of converging attacks. In scientific work this means simply that the best results are likely to be obtained by means of team work, any problem being simultaneously examined from as many aspects as possible. The different sections of the Research Institute, therefore, however specialised their own technical methods may be, cannot work as isolated units, but their work must be co-ordinated in the closest possible manner if reasonable progress is to be made. I have stressed this question of team work because I want to make it perfectly clear that I regard each individual planter as a member of the team and count upon his full support and co-operation in our work. It is impossible for this Institute to carry on successfully without such co-operation, and I am perfectly confident it will be accorded in full measure.

In the present Conference you will have papers presented to you covering four main questions, soil amelioration, control of insect pests, pruning and manufacture. The subject matter of these papers has been deliberately chosen not only because of the intrinsic importance of the ground to be covered, but even more to provide scope for a discussion of the widest possible character and I do express the hope that as many as possible will take part in the discussions. It is of great importance, and it will be of the utmost assistance to the Institute Staff, if the views of different schools of thought on the various matters raised, receive full and adequate expression. Most of you here are planters of wide practical experience and we ask you to give us the benefit of that experience by your criticisms and suggestions. It is obvious that in most routine planting operations, such as cultivation, pruning, manufacture, etc., there is a considerable difference of opinion among planters as to what constitutes the best practice and I hope the protagonists of such different views will give us details of the methods they advocate and their reasons for adopting such methods. A discussion of this sort would be of the greatest value and help us materially in deciding whether our programme of work is based on sound premises, besides suggesting new lines of attack.

I have already discussed in the last August number of *The Tea Quarterly* certain problems which seem to be of primary importance. In that article considerable stress was laid on the importance of a physiological study of the tea bush and work of this kind is now in progress. Such a physiological study has a wide implication, since it may be expected to explain the reaction of the bush to different methods of treatment and may thus throw considerable light on such questions as manuring and pruning. The latter undoubtedly is one of the chief questions awaiting full investigation. There is, I think, a fairly general move in the direction of lighter pruning and, as a result of this, we may reasonably expect a decreasing loss from the so-called Diplodia. But such methods, *e.g.*, cutting across, raise their own problems which will be discussed in one of the papers tomorrow. In relation with pruning must also be considered the best use of pruning mixtures. Here again estate practice differs considerably, both in regard to the composition of the pruning mixture and the time of its application and definite experimental work on the subject is clearly needed.

In regard to insect pests, termites, tea tortrix, nettle grub and shot-hole borer are the outstanding problems. As you are aware the work on termites is at present carried out by the Department of Agriculture. I wish, however, to refer to this pest today because in many districts this is probably already the most serious pest of tea and there is every indication that the situation is likely to become

materially worse. I understand that Dr. Snyder of the United States Department of Agriculture, and the leading authority on termites, has been commissioned by the Indian Government to visit India towards the end of the present year and that he will spend several months there investigating the termite problem. In view of the widespread damage caused in Ceylon by this pest, not only to major crops but also to buildings, it would appear that advantage should be taken of Dr. Snyder's presence in this part of the world to obtain the best possible advice. The pest is of island-wide importance and I hope, Your Excellency, that in the event of representations being made to the Government that Dr. Snyder should be invited to visit Ceylon before his return to America, such a request will receive your sympathetic consideration.

In regard to Tortrix considerable progress has now been made elucidating the reasons which have hitherto hindered the large-scale production of the Tortrix parasite in Ceylon. With the better facilities now available, I have reason to hope that the work will now advance much more rapidly, enabling this method of control to be tried out in the field.

Steps are also being taken to widen the scope of the work on Nettle Grub which is proceeding on two main lines, *i.e.*, control by sprays and dusts and a search for suitable parasites. The question of laboratory and housing accommodation for the staff engaged on this work, which is being carried on in the Passara area, is however, one of the chief difficulties at the moment, since the Institute is hardly in a position to undertake capital expenditure of this kind away from headquarters.

As you are aware, an application was made to the Empire Marketing Board for a grant to meet the cost of a comprehensive survey of insect pests and their parasites in Ceylon. No definite reply has yet been received and it is believed the delay is due to the fact that the Board is considering a survey of wider scope embracing several Eastern countries. In view of the fact that such an extension may indefinitely hold up the inception of work in Ceylon, further representations have been made for a sympathetic consideration of our original scheme.

In regard to fungus diseases, root diseases, and Poria in particular, continue to be one of the chief problems. With Poria no satisfactory method of eliminating the fungus from the soil is yet known and in case of attack the precautions which have already been described in *The Tea Quarterly* should be carefully followed if the attack is to be localised.

Another disease which may, perhaps, deserve further attention is that of "Witches Broom," a term which probably covers more than one disease. There is some evidence that Witches Broom is more prevalent than is usually supposed and, in one form at any rate, spreads slowly from bush to bush. No causative fungus has been isolated and it is possible the disease may be of a virus nature, in which case, it is suggested by Dr. Gadd, that the infection is possibly spread during pruning.

I must pass on to say something regarding field experiments. Manurial plots to investigate the effect of nitrogen and potash in different proportions and of different forms of nitrogen have now been laid down at St. Coombs. A series of demonstration plots for green manure cover crops has also recently been prepared, in which the suitability of some twenty different varieties will be studied. Drainage experiments have also been initiated and these will be further implemented in the new clearings which are to be planted up during the present year. A portion of this new clearing will be definitely experimental in character, different methods of treating the patna being employed, while the stumps used will also receive different treatment before planting out.

I should perhaps say a word about future developments in field experiments. It is the policy of the Institute, when financial conditions permit, to open up small sub-stations in different areas and particularly in the low-country. It will be some time before this can be done but this does not imply that we shall remain inactive in the meantime. This question has been carefully considered by Mr. Eden and we are hopeful that it may be possible, with the co-operation of estates, to arrange for some field trials of limited scope away from St. Coombs, the experiments being laid out by the Institute and the subsequent observations carried out by the estate and Institute Staff in colloboration. The details of such experiments have not yet been worked out and I only refer to them at this stage to indicate that we are not unmindful of the necessity for work in other areas than St. Coombs.

I do not propose to refer, except in a few words, to manufacturing problems, because these will be discussed in detail in the paper which Dr. Evans is to give you tomorrow afternoon. But a very comprehensive programme of work has been mapped out, in which the various processes of manufacture, withering, rolling, fermentation, etc., will be fully dealt with, while, at the same time, the chemical changes taking place during each process will be followed up in the laboratory. Valuable data in regard to manufacture have been accumulated and you will have at your disposal tomorrow full details of the factory practice at St. Coombs.

Our Factory is now being equipped with small-scale experimental machinery which will enable manufacture to be carried out with small quantities of leaf under widely varying but strictly controlled conditions. You will have the opportunity to see tomorrow the first units of this small plant. These are necessarily experimental in more senses than one, but any improvements which experience may show to be desirable will be incorporated in the later units and I believe these will prove a most valuable asset to the experimental side of the factory.

It only remains for me, gentlemen, to ask for one further indulgence on your part. You will, I am sure, appreciate that much of the work which I have referred to is long-range in character. I can assure you that in our programme the practical aspects of the subject will continually be borne in mind, but useful practical advice can only be based on accurate scientific knowledge. The acquirement of such knowledge is a matter of time and will call for some patience on your part. The increasing number of enquiries, however, received by the Institute encourages me in the hope that already the Institute has been of some service to the tea industry. With the facilities now at our disposal I confidently trust that our scope of usefulness will be correspondingly enlarged.

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At this stage, His Excellency left the Conference and the chair was taken by Mr. A. G. Baynham, Chairman, the Planters' Association of Ceylon.

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# CULTIVATION AND SOIL IMPROVEMENT.

T EDEN.

## INTRODUCTION.

The beginnings of agriculture as a science date back to the commencement of the nineteenth century. The considerable progress that has been made in the intervening hundred and thirty years has been, as is generally the case, discontinuous progress. It has been spasmodic, in that our knowledge of the relationship between soil and crop has developed markedly first in one direction and then in another. The pioneering work of last century was concentrated on the question of plant nutrition, so that even a shrewd observer such as Sir Henry Gilbert speaking of crops in general condensed his message to agriculturists into the words: "If you won't feed us, we won't grow." There is no gainsaying this maxim nor the fact that it captivated the imagination of agriculturists. What is now equally evident is that it has been allowed to dominate our conceptions, and that we are in danger of giving the gospel of putting something into the ground marked precedence over that of making good use of what is already there.

During the three or more years during which I have been informing myself of the trend of agricultural practice in Ceylon, more particularly as it relates to tea, I have been struck by the pre-eminence that is given to manuring in the minds and routine of the planting community. For that reason I have chosen to alter the emphasis in what I have to say today in order to bring before you the claims of soil cultivation, meaning thereby the processes, mainly mechanical, by which soil is brought into that state of texture suitable for the healthy growth of crops. It will be my prime object to insist in the words of Sir Daniel Hall "that the productive capacity of a soil is determined far more by its physical condition than by its content in the elements of nutrition."

## THE MAINTENANCE OF TILTH.

The physical state of the soil largely controls the moisture supply and the composition of the soil-solution upon which the plant depends for a large part of its nutriment. Not less important are considerations of soil æration and temperature which can be traced to the same source. The efficiency of soil as a medium for plant growth thus primarly depends upon questions of texture or tilth and any other aspect of growth and nutrition has ultimately to be related to this soil condition.

The degree of tilth and texture largely evades scientific measurements. It is definitely known to be dependent on the grouping of the unitary soil particles. A soil where particles of varying size are aggregated in compound crumbs is in good tilth; where the crumb structure is predominant, excessive stickiness when wet and lumpiness when dry, two characteristics of poor soil condition, are relatively absent. It should be the agriculturist's main concern to produce this crumbly structure and to maintain it in the face of weather and other conditions which constantly tend to destroy the desired state.

Mechanical cultivation is one way of achieving this end, not only by breaking the hard lumps which form, but by providing opportunities for other and more universal forces which operate in the innermost recesses of the soil where neither plough nor fork can penetrate. It will help our understanding of cultivation as a factor in the production of tilth if we consider these in some detail.

## NATURAL AGENCIES FOR TILTH PRODUCTION.

First of these natural agencies is frost. The breaking up by frost of the "cemented" lumps of soil into smaller units which can aggregate themselves into the looser conditions of soil crumbs is one of the most potent factors for the production of good tilth.

Next comes the alternate drying and wetting of soil which causes shrinkage and swelling. In the process of swelling rupturing forces are exerted which tend to change the relative positions of the particles. Further, when the soil shrinks its volume is not identical with what it first occupied and so here again the relative positions of particles are altered.

Lime is also a potent factor in flocculating soils, *i.e.*, in bringing them into a non-sticky state, and it was largely used in traditional agricultural practice for this purpose even before sourness and acidity of soils was an agricultural shibboleth.

Earthworms are active soil cultivators. In their search for food they pass large quantities of soil and dead plant tissues through their digestive tracts and play a slow but almost continuous rôle in the mixing of particles of all sizes.

Finally there is soil organic matter—humus—which acts in a dual capacity. It forms round soil particles a jelly-like coating which is particularly susceptible to flocculation, and it enhances whatever swelling capacity the soil already has. Taken together these five factors represent very powerful natural agencies supplementary to those which the cultivator himself controls.

You have no doubt been saying to yourselves as you have listened to this recital that some of these factors are inoperative under our conditions. Actually, all except the last—humus—can be ruled out. We have no frost; apart from soils rich in humus, Ceylon soils are exceptionally poor in shrinking and swelling capacity. Applications of lime in quantities requisite for bringing about marked flocculation are not to be recommended in the case of a crop which prefers the acid side of the soil reaction scale. Because of this preference for acid soils, the activities of earthworms are minimised. Arrhenius in his study of earthworms in relation to soil has shown that earthworms can barely drag out an existence in soil having a value below 6 on the so-called PH Scale, *i.e.*, having a reaction which all the data accumulated so far show to be eminently suited to the physiological requirements of the tea bush.

Two important considerations emerge from this discussion, firstly that mechanical cultivation under our climatic conditions has a bigger burden to bear than in temperate climates, and secondly that the efforts to make use of natural agencies have perforce all to be concentrated on the accumulation of organic matter in the soil.

## CULTIVATION: OBJECTIONS AND REMEDIES.

There appears to be no consensus of opinion as to what constitutes adequate cultivation for tea in Ceylon. One meets with estates where cultivation is carried out only at the time of the annual manuring with artificial manures, that is to say where the soil is cultivated

only once in two years owing to the practice of forking alternate lines only. According to locality and methods of green manuring one meets with every gradation from this meagre treatment to that of two rounds per annum, the latter being the most frequent I have personally seen. When one takes into account the relatively mild form of cultivation, the intensity of the factors which destroy tilth and the nature of the average tea soil, even the most intensive of these examples is by no means excessive. A comparison with the practice on temperate soils under intensive fruit culture for example, is strongly in favour of the latter.

There are three common objections to intensive cultivation:

(1) It stimulates soil erosion.
(2) It is prodigal of supplies of organic matter.
(3) It increases the risk of root damage.

Treating these in turn, the argument for the first objection rests mainly on the soil erosion experiment carried out at the Experiment Station, Peradeniya. A casual inspection of the results obtained there suggests that 'forking' in comparison with 'no cultivation' produces an excess of erosion to the extent of some 32%. A trial of this nature is faced with peculiar difficulties, and the Peradeniya trial has encountered more than its fair share of these. A detailed examination of the results shows that the experimental error of the results is as high as 40% and that conclusions definitely derogatory to forking are not justifiable.

A similar experiment conducted by the Missouri University Experiment Station also gives negative results, but both are capable of throwing light on difficulties. It appears from the statistical examination of the results made in our laboratories that the different plots in neither case behave concordantly from year to year. Evidently the individuality of the forking and its reaction to weather conditions is the vitiating factor. It has been necessary to deal with these frequently quoted experiments in parenthesis in order to anticipate justifiable criticism.

I conclude that the effect of forking on erosion is still an open question. Cultivation cannot, however, be discouraged meanwhile. The fact is that an uncultivated soil preserved whole is still one that is not rendering the best service for the particular end in view, viz that of crop production.

The second objection is much better substantiated. Cultivation undoubtedly accelerates the micro-organic activities which destroy organic matter. In so far as the destruction provides the bush with nutrition which would otherwise be inaccessible, it is good. The fear is lest the destructive pace as it refers to soil organic matter may exceed the constructive pace of the growing plant and involve loss.

The remedy for both these dangers is one and the same, namely that of combining all cultivation operations with the utilisation of green manures. A really porous soil develops no run-off. A highly 'cemented' soil may escape with relatively little; it is the intermediate state—that state of porous surface layer with a stubborn pan underneath that contributes largely to the damage.

Adequate green stuff will maintain the porosity, and if a cover crop is grown *in situ* it places an immediate check on erosion; even if the cover is partially destroyed by cultivation, the soil remains both anchored and porous. By means of a cover crop the supply of organic matter is maintained and the humus into which it is converted is itself a natural agency for the maintenance of tilth. My argument resolves itself into a recommendation to intensify one producer of soil tilth, namely green stuff, in order to minimise any soil erosion loss which may perhaps be inevitable in the use of another beneficial weapon, namely cultivation.

As for root damage, I can well imagine that this is likely to occur in a soil where inadequate cultivation has concentrated the root system at a shallow depth, and where the fork used at long intervals has to overcome the resistance of a hard caked soil totally devoid of tilth. No unequivocal case of root damage has come to my personal notice on estates where more frequent cultivation is the practice, and reports from India where green jungle has to be dug in as frequently as once in six weeks have been singularly free from this criticism. By regular cultivation a deeper rooting system is encouraged and the leverage of the fork in a soil not totally devoid of tilth is far less likely to produce the much feared damage.

It only remains to gather up the main points of my argument. Cultivation and the consequent production of good tilth, is fundamental to successful agriculture. In Ceylon it falls short of the standards maintained in established systems of agriculture elsewhere. This is the more serious since natural agencies are of little account.

The admitted difficulties in tropical soils can be minimised by the co-ordination of green manuring in its various aspects with cultivation operations, particularly by cover crops regularly dug in. Such a co-ordination preserves the soil, enriches the humus supply, controls the cover crop and, most essential of all, maintains the tilth.

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**Mr. Huntley-Wilkinson,** Gentlemen, Mr. Eden in his excellent paper has stressed the necessity of increasing tilth. I propose this afternoon to outline a few ways in which this can be done—at any rate in the District of Dimbula at an elevation of between 4,000 and 5,000 feet above sea level.

The prevention of soil erosion is one of the first methods to attain this object,

Now there is only one possible way of preventing erosion and that is to stop it occurring at the source or in other words *in situ*. All the methods one sees stressed in this Island, such as terracing, contour draining, silt-pitting, and so forth are very estimable in their way but they are, as pointed out by the Tea Reesarch Institute, really only a second line of defence.

The only way to prevent erosion where it actually occurs is to establish a ground cover of some sort. Perfection of ground cover and in fact perfection in anything, is an impossibility in this world, but to my mind the ground cover which as nearly as possible is a perfect one for tea in this district is "*Oxalis corymbosa*"—with *Oxalis latifolia* a good second.

It must be granted that Oxalis, not being a legume, would not be as nutritious to the soil as other leguminous ground covers such as *Indigofera endecaphylla*. But the latter has one great disadvantage from the planter's point of view and that is that, especially in forcing climates, it costs a certain amount to control. This does not rule it out entirely because if a thing is worth growing it is worth the trouble of control. After all, if we did not control our Dadap shade, our estates would be a "sight for the gods." Another non-leguminous but useful cover crop is *Drymaria cordata* and the great objection to this is that if not attended to strictly every month (by the weeders pulling it away from the boles of the bushes) it will interfere with the plucking table. I can point to an estate in Dimbula where Drymaria has been established as a cover crop for over two years and where the weeding bill is less than Rs. 2 per mensem and where the Drymaria has never been allowed to interfere with the plucking table.

There is however a leguminous ground cover being tried on another estate in Dimbula which I think will be found easy of control and that is *Cassia Leschenaultiana*.

Other ground covers being tried up-country are *Centella asiatica* (the Violet Weed), *Artemesia vulgaris* (the wild Chrysanthemum), *Rungia latior* (or what the Tamil cooly calls "Soonuboo Pillu") and *Parochetus communis*. The latter is a legume and if it will thrive in dryer parts of the estate should prove most useful. We are indebted to Mr. Oliviera of Lippakelle for bringing this into prominence. I personally am trying some ten or twelve other promising indigenous plants as ground covers, some of which I hope to prove useful.

Another method of increasing tilth is the establishment of nitrogenous bush plants in alternate rows of tea and using their foliage by incorporating it with the soil at the time of applying artificial manures and thatching the ground with the same at other times when they threaten to "overshade" the tea.

Literally tons per acre can be added in this way every year if one takes into consideration the weight of Dadap loppings and of dead tea leaves which can be incorporated at the same time. This in itself will go a long way towards taking the place of recurrent losses of soil which one sees merging with the waters of our larger rivers as they find their way to the sea. One often hears it said that these bush plants will compete with the tea for the artificial manure; but I know that the scientific officers of this Institute will bear me out, when I say that they merely hold up this plant food in suspense and eventually return it to the land when they in their turn are assimilated into the soil. It is strange that one never hears this argument applied by those who grow the Dadap (*Erythrina lithosperma*) at intervals of 12 feet in their tea.

Another method of increasing tilth is open to those who can apply cattle manure to their tea but a 24-lb. basket to two tea bushes means an application of 16 tons to the acre.

*Erythrina lithosperma* or the homely Dadap is perhaps the most used legume of the higher type at the elevation I am talking about, but I would sound a note of warning with regard to it. If severely lopped at any rate, it threatens to withhold some of its great weight of leaf because in parts of the Island it is handicapped by eel-worm attacks.

The method employed by Mr. Gordon Pyper of stripping its leaves (instead of severely lopping at the time of application) I find considerably lessens this trouble and has the effect of bringing the trees back into foliage very quickly.

*Gliricidia maculata*, I am afraid, will never take the place of the Dadap in the zone I am talking about because it does not thrive here. I have hopes that some of the following can be grown large enough to take the place of the Dadap if necessary: *Cassia auriculata Indigofera stachyoides* (which is the same as *Indigofera dosia*), *Cassia didymobotria* and *Cassia semperflorens*. I am not at all sure that even *Tephrosia Vogelii* and *Cassia hirsuta* will not prove large enough for this purpose if left to grow a long enough period. The *Acacia decurrens* is favoured and by some *Crotalaria langopes*, but this has been found to be severely attacked by caterpillar on one estate in Dimbula and I would not recommend its establishment on any large scale.

So much for legumes of the variety grown for lopping purposes as opposed to those grown for pruning and uprooting at intervals. The next type of tilth supplier I would like to discuss is what one hears referred to as high shade left to grow into big trees. The *Grevillea robusta* is a prolific supplier of soil renewing material. One wonders why in Ceylon it is not trained, as it is in South India and

I believe in parts of South Africa, to grow in the form of umbrella shade—the radius over which it can then shed its leaves is far wider than when left to grow up naturally.

One often hears it said that Grevillea cannot be established in old tea; on the other hand one actually sees it being established quite successfully on some estates. The great enemy of its establishment is the cooly who uses the foliage as a household broom and as a means of filling holes in his or her basket, and its bole when it is just forming into a tree as an easily acquired Attali.

I know a planter who lives not so very many miles from here who buys coir brooms for his labour force at about 9 cents each and charges the cost of them to an item in his accounts called "Timber Establishment:"

*The Albizzia moluccana* grown at, say, 60 ft. intervals is favoured by many as a means of supplying both chequered shade and a good crop of leaf droppings. I must say that to my mind tea growing under Albizzia always looks extremely healthy.

The Dadap also is often seen allowed to grow up into big trees for the same purpose.

Up to about 15 years ago Dimbula estates carried quite a quantity of high shade. About then a new school of thought came along and one heard it preached that the proper place for timber trees was in the ravines and many thousands of yards of Grevillea firewood were removed from the tea.

Since then many planters have come to the conclusion that shade is beneficial to tea and many thousands of rupees have been spent in endeavours to re-establish it.

I have heard it said that coffee would still be with us had it been grown under high shade as is now being done in India and Kenya.

To return to the question of the incorporation of green manures with the soil by means of the fork—

An estate in Dimbula which claims to put out annually over 3 tons of green stuff and only applies 400 lb. per acre of an organic manure mixture has yielded over 750 lb. per acre during the last five years. The estate runs from about 4,300 ft. to about 4,800 ft. and the pruning cycle is one of 36 months.

No special pruning mixture is applied, but a well-balanced general mixture at the rate of 400 lb. per acre, giving 25·71 lb. nitrogen, 37·43 lb. phosphoric acid and 21·43 lb. potash per acre is applied at the time of pruning and every 12 months after that. For about the last 10 years all the available loppings from the Dadaps (well established at intervals of 12 feet) have been buried, the land being forked on the envelope system. This has been done in alternate lines of the tea.

During the last 2 years the green manuring system has been considerably extended by the establishment of nitrogenous bush plants in alternate lines of the tea.

The seed is sown in the forked line after pruning (and incidentally, Oxalis bulbs as well where this cover is not already established). It has been found that the resultant bush plants require to be pruned every six months.

When the annual forking takes place the resultant green stuff is buried under the fork. At other times it is merely lopped over the land. The bush-plants are eradicated in the 24th month from pruning and there is no green manure shrub growing between the 24th and 36th month, except at intervals of 12 bushes or so for the purposes of seed collection.

When the field is again pruned and forked, it will be found that the forked line is the one other than that in which the bush plants were growing previously. Seed is then sown again in this alternate forked line and the same cycle will be gone through again. Thus the line in which seed is sown today does not have seed sown in it again for a period of six years.

The actual cost of application of artificial and green manures last year on the estate I am referring to (inclusive of transport of artificials to the field) worked out at an average of Rs. 7·52 per acre. Seed cost the estate nothing as it was able to supply its own wants and to sell the surplus, proceeds of which were used for other soil erosion preventive measures on the estate.

Until bush plants are established to supply seed it will be found that the larger seed (put out at about 3 lb. per acre) is costing about Re. 1 per lb. and the smaller (at about 2 lb. per acre) is costing about Re. 1-50 per lb. So that the cost of seed will be in the region of Re. 3 per acre.

The bush plant most favoured by the estate in question is *Tephrosia Vogelii* (seed of a large size) and the next to that *Cassia hirsuta* and *Indigofera arrecta*. (both small seed.)

For some reason *Crotalaria usaramoensis* does not thrive here and it also has the disadvantage of a caterpillar which eats the seed.

Further up in the Agras *Crotalaria usaramoensis* does splendidly and has been found most useful. In Uva I am told a caterpillar attacks the seed of *Tephrosia Vogelii*.

Other estates in Dimbula have had success with the following:—

*Cassia divaricata*, *Tephrosia candida* and *Crotalaria anagyroides*.

The most useful in my experience are *Tephrosia Vogelii* and *Cassia hirsuta*—the latter combines a profusion of green stuff and also supplies a nice chequered shade to the tea. It however does not seem to carry any nitrogenous nodules and is somewhat tenacious

when eradication is required; a quintanny, however, gets over this difficulty. Three tons of *Tephrosia Vogelii* to the acre is equivalent to a supply of very nearly 20 lb. of nitrogen. One wonders why this should not take the place of a great part of the ingredients of the organic manures one pays such a lot of money for, in so far as the nitrogen supply is concerned at any rate.

There is another estate in Dimbula which actually allows all its weeds to grow and thrive for three months at a time before eradicating same; they are then dug in but, this means a forking of the land four times a year. The Superintendent claims that he actually forks into the soil as much as 20 tons of green stuff to the acre by this means during the first $2\frac{1}{2}$ years after pruning. The majority of this application is derived in the first 18 months because as the bushes grow larger the weeds become fewer.

As far back as in 1900 the late Mr. Kelway Bamber published a report on Ceylon tea soils and recommended intensive measures of green manuring. He particularly mentions a plant called *Adhatoda vasica* whose leaves are rich in nitrogen. He says that this shrub grows up to 4,000 ft. and possibly higher as a fence for cooly gardens. The late Mr. A. L. Scott told me subsequently that it thrived as far up as Waverley.

In bringing this paper to a close, I would again stress the point that what Ceylon soils require is tilth; and that there is no purpose served by merely putting on the land a quarter of a ton of fish solids to the acre if measures are not taken to see that they do not return to the sea whence they came.

## DISCUSSION.

**Mr. C. Bruce Foote** said he would like to supplement Mr. Wilkinson's remarks on one or two points. Firstly with regard to *Indigofera dosia* which was introduced from Darjeeling some ten years ago. He had tried it in young clearings in the low-country where it was a complete failure. Mr. David Cameron, to whom he had given seeds, tried them on Craighead with fair success and he was pleased to see it thriving on Mr. Wilkinson's estate. Since his friends in Darjeeling said it did so well in that climate, he suggested that it might be tried in the Nuwara Eliya and Kandapola districts where Dadaps would not grow.

Another species not referred to by Mr. Wilkinson was *Derris microphylla,* although he had seen it on Mr. Wilkinson's estate and in the Kelani Valley. To his mind it was an ideal high shade plant giving a delightful chequered shade. If it had not been that he did not wish to anticipate the Soil Erosion Committee's Report, Mr. Wilkinson could doubtless have added more interesting things and he hoped the T. R. I. would press for the early publication of that report.

**Mr. W. J. Rettie** said that he gathered from Mr. Eden's remarks that Mr. Eden considered that cultivation in Ceylon was receiving inadequate attention. Whilst agreeing, he suggested that cultivation of an intensity inadequate in temperate zones might be adequate in tropical climates. He believed it was Mr. Joseph Fraser who had pointed out that yields were what they were rather because of the forcing effect of climate than because of applications of manure, and the same argument might be used with respect to cultivation.

In connection with the use of green manures he asked Mr. Eden whether it was better to fork in the green stuff separately and then scratch in the artificials with a hand fork later, or whether one was justified, as he himself thought was the case, in forking in green stuff and artificial manures at one operation.

**Mr. T. Eden** in reply stated that he should continue to maintain that Ceylon cultivation was inadequate until Mr. Rettie's suggestion that tropical soils required less vigorous treatment than temperate ones was backed up by a convincing reason.

He thought that whilst it was true that the climate was more forcing, it was equally true also that as an agent for the destruction of tilth and for undoing the work of cultivation it was more intense. He was sure that the climate in tropical places like Ceylon provided an argument on his side.

Referring to the practice of putting in artificial manures with green stuff, he agreed with Mr. Rettie. Particularly with reference to nitrogenous manures, the practice was beneficial in helping to rot down any rather woody tissues that was included in the green manure. By doing the two operations at once, one saved extra labour and one incorporated the manures with the soil at a depth suitable to the range of the feeding roots of the plant.

**Mr. T. H. Holland** suggested that the lack of cultivation in tea was compensated for by the root action of trees like Albizzia planted amongst tea. He also thought that root damage from cultivation might be very real though on casual inspection undetected; nevertheless it might be that on balance the policy of more intensive cultivation was superior.

**Mr. T. Eden** replied that the question of the root effect of interplanted trees would bear further examination. If these trees were putting out roots at the same depth as tea there was the effect of competition to consider. If on the other hand the roots were deeper, then he admitted that some sort of sub-soiling effect might be produced which would be markedly beneficial. A sub-soiling effect did not however dispense with the necessity for thorough cultivation of the top soil by envelope forking.

With regard to root damage, when he referred to having seen no unequivocal damage he was not confining his meaning to examination of the roots, but to the subsequent behaviour of the crop and the yields produced.

**Mr. Wilmot A. Perera** said that on some estates where forking was carried out four times annually with the application of artificial manures, bad results were obtained in dry weather. He himself forked twice a year with a great deal of green manure and had excellent results.

**Mr. T. Eden**, after asking Mr. Perera, if he attributed the bad results to the forking or the continual use of artificials, replied that he saw very little point in cultivating with artificials only several times a year. His main contention was that any incidental disadvantage that might be unavoidably associated with cultivation was removed by always combining cultivation with the incorporation of green stuff.

**Mr. J. Horsfall** drew the attention of the Conference to a number of green manures he had experimented with on the dry side of the Island as possible substitute for Dadaps in localities where eel-worm trouble was prevalent. *Atylosia rugosa* was struggling up slowly on a poor soil, but it flourished in the sun. *Derris robusta* and *Dalbergia Assamica* were also on trial: the latter started slowly. *Derris dalbergioides* he had seen at Peradeniya, but parts of Uva appeared to be too high for it. It might be brought up gradually and care would have to be taken in pollarding it. He thought Mr. Carpenter would be able to give a word of warning about *Indigofera dosia*.

**Mr. P. H. Carpenter** said that *Indigofera dosia,* though supplying large amounts of green matter to the soil, had been done away with in many areas. It was usually grown in the lines four or five rows apart and allowed to continue in growth for five years, which in the Darjeeling district would correspond to a pruning cycle. It was then removed, but, as the roots were very difficult to get at, what usually happened was that it was cut off level with the ground. As a result of leaving the roots, the tea on either side died out as a result of root rot. *Derris robusta,* previously mentioned, had resulted with them in the introduction of a disease referred to as Black Blight which left a sooty mould on the surface of the leaf.

**Mr. Bruce Foote**, asked if *Indigofera dosia* might be left to grow permanently as high shades, thus obviating risk of root from decaying stumps.

**Mr. P. H. Carpenter** saw no reason why this policy should not be adopted but had no experience of that method.

**Dr. W. S. Shaw** commented upon the mention of frequent cultivation of succulent weeds in S. India. He pointed out that to dig in weeds meant the abandonment of clean weeding. In S. India weeds were allowed to grow during the monsoon, but were cut down and forked in as soon as the field became untidy. After the monsoon the fields were clean weeded. He remarked on the apparent absence of Grevilleas in Ceylon as judged from the railway journey up-country. In S. India Grevilleas were the predominant shade tree and he considered the most important. They were lopped at varying heights between 10 and 20 feet. He recommended 18 ft. as a suitable height. He was a strong supporter of regular cultivation and some estates cultivated at least four times a year. He had seen neighbouring estates, cultivated and uncultivated, and the advantage lay with the cultivated estates, both in yield and appearance.

He knew one district possessing an excellent soil with a nitrogen content of around 0·4% which was considering intensive manuring, whereas advantage should have been taken by means of cultivation of the food material intrinsically present in the soil. He considered cultivation to be one of the finest treatments for tea.

**Mr. C. Huntley Wilkinson** asked at what age Grevilleas should be pollarded in order to give a liberal shade.

**Dr. W. S. Shaw** said that pollarding was unsuccessful with old trees and that they should be cut at about 18 ft.

**Mr. Bruce Foote** asked whether the superior growth of Grevilleas in S. India was not a matter of more favourable climatic conditions.

**Dr. W. S. Shaw** replied that he was not sufficiently acquainted with Ceylon conditions to give an opinion.

# CONTROL OF INSECT PESTS.

C. B. REDMAN KING.

If circumstances were such as to permit the natural increase, without check, of a single species of insect, the surface of the earth would, in a short time, be completely covered with them. As there are some half-million and more known species of insects, not to count the vast number of other animals, we may infer and prove it to be true that there is a great slaughter constantly in progress. This, of course, is one of the basic arguments set forth in the "Origin of Species" wherein the "struggle for existence" is emphasised.

Suppose we penetrate some primeval jungle, we shall see a dense undergrowth of plants of different sorts competing for nourishment in the soil, and trees reaching up, striving for a place in the sun. If we are sufficiently observant, we may see a moth fluttering about and laying eggs on plants destined to become the food for its progeny. Some of the eggs may fail to hatch, others get eaten or parasitised. Of the remainder which hatch, some die of constitutional weakness, others are attacked by ants, wasps and birds, or may fall victims to disease, or their food may run short. In the end, perhaps 1 per cent survive to carry on the race. This competition for existence is, in reality, a vastly more complicated affair than here indicated, depending as it does on ever-widening circles of inter-related factors. But, generally speaking, it may be said that a balance is struck between the various forms of life in a circumscribed area, which will vary only by small amounts and within fairly narrow limits. A large variation in any one factor may throw the whole completely out of balance. For example, a well-intentioned planter arrives on the scene and clears an area of jungle and plants it up with one crop. Our friend, the moth, discovers that this is just the stuff for its young, and consequently leaves its old haunts for pastures new. In due course follows an outbreak of caterpillars with disastrous results to the crop. It is reported to a central authority, which solemnly dons the black cap and makes it a notifiable pest; and it will probably have its effect, too, on the prices quoted for raw material in the exchanges of the world.

The nice balance that formerly existed is now upset by the extensive growth of a single plant. It immediately favours those insects which can feed on it. They do, of course, offer now large masses of food to their particular enemies, but they have had their innings first; and it often happens that for some reason their enemies are not able to take advantage of this opportunity. The result is a number of first-class pests, which take heavy toll of our crops:—wheat, maize, rice, cotton, tobacco, sugar and tea, to mention some of the leading staples.

Let us now consider in more detail some of the forces brought to bear on insects in nature:—

(1) Shortage of food may be brought about by decrease of the food plant or by excess of individuals. Such a condition may lead almost to the annihilation of an insect species.

(2) Of insect enemies, parasites are usually more important than others. They are dependent on the numbers of hosts available, and if a large number of the requisite host is available for a long period, the host may be reduced almost to vanishing point. This, however, will have a profound reaction on the parasite which now will have a very great numerical superiority. The host insects being almost exterminated, the parasite is left without being able to propagate and consequently will almost die out likewise. The result of this is twofold. At first, the crop will be remarkably free from the pest in question, but it gradually works up again and this time having far outstripped its parasite, may ravage the crop far worse than before.

(3) Diseases of various kinds take their place in the scheme of things. They may be of fungal or bacterial origin, or perhaps be due to a virus. Wilt attacks many caterpillars at certain times and may be ascribed to a virus until something more is known about it.

(4) Climatic effects are of great importance in the complex of insect life. Excessive high or low temperatures produce dormancy or death, and the same may be said of excessive drought or humidity. No insect activity is seen at the Poles or in the Great Gobi. In regions subjected to a continental climate, *i.e.* with a great range of heat and cold, insects have adapted themselves to these extremes by their ability to aestivate or hibernate, though even here excesses may prove fatal. For example, the boll weevil of America, which plays such havoc with the cotton crop, can hibernate, but a severe winter will kill off large numbers. The type of winter experienced there has its effect, therefore, on the "Futures" cotton exchanges.

All these considerations make up a complex which may be taken into the account of the "Struggle for Existence." The important point which emerges from it is the limitations imposed on populations living together in any given area. The factors act and react among themselves. There is a well-known complex in which the quality of beef in some parts of Britain depends on the number of cats in the neighbourhood. The beef depends for quality on clover which is only fertilised by Humble bees. The nests of the Humble bees are raided by mice which are themselves attacked by cats. The more the cats, the fewer the mice, the more the bees, the better the clover, a regular sort of "House that Jack built."

If we want to help ourselves in the fight against insects, we must first make our way into the great labyrinth of conflicting forces in an endeavour to study the plan. Only so will we be able to take a leaf out of the book of Nature, and, by the introduction of new factors not already existing, deliberately create a new balance in our favour. The only forces at our disposal to play with are diseases and enemies.

Experiments, designed to encourage the propagation of insect diseases, have for the most part met with failure; we shall, therefore,

not now consider them. On the other hand it has been possible to make use of insect enemies to control pests and, though in a few instances remarkable results have been achieved, they represent a small proportion of the attempts so made, and have been obtained under somewhat specialised conditions. These particularly favourable results have been attained where pests were originally introduced from outside into a well-defined circumscribed area of small dimensions such as an island. When the pests make themselves known, a search is made for their parasites in the country of origin. The two points of importance to be noted are—firstly, the limited area, and secondly, the fact that the pest was not indigenous.

The procedure adopted is to breed the parasites in their natural home, and then to despatch them to their future home in a parcel containing sufficient food to keep them alive on the way. If the period of transit exceeds the time of development of the parasites, they are shipped in cold storage, so that they pass most of the journey in a dormant condition. On arrival, they are transferred to the laboratory where development is completed and a new cycle started. Numbers may be thus bred and liberated at the appropriate time, *i.e.*, when the pest is about to become abundant. In a favourable climate a few such releases may be all that is required. The most favourable conditions are those permitting continuous propagation. A locality subjected to a succession of different seasons is not usually favourable in this respect. The reason for this is not far to seek. If, as in the case of Tortrix, the moths are only active for a month or two at a time, succeeded by a period of two or three months when there is no activity, the egg parasite, for example, can only flourish when egg masses are abundant. But as the parasite only takes two or three weeks to complete its development, it cannot survive in the intervening period. In actual practice, a very insignificant number do so, probably on chance eggs of various other moths. If conditions were such that Tortrix bred continuously, there would very possibly be no Tortrix problem, since the parasite would be greatly favoured by eggs always being on hand.

It may be permitted, for a moment, to touch upon the special problem of the Tortrix egg parasite. It has been chosen among several others for an experiment in natural control owing to the ease with which it may be had in large numbers, and also because it has no parasite preying on it. The central idea is to supply the deficiency caused by the blank periods previously alluded to. These periods, to repeat, bring about the destruction of the parasites through lack of hosts. If we can throw into the field a large number of parasites just when the Tortrix begins to get busy, so that in a short while it will increase to much larger numbers, we hope they will be able to

keep the Tortrix down. As things are at present, there may be, at the start of a season, one parasite per million eggs. We want to start with, let us say, ten thousand parasites per million eggs.

Let us now turn to other possibilities in control. The foregoing brief review refers to what is generally known as Natural Control, meaning the amplification of methods already existent in nature.

The next consideration is Artificial Control, which may be subdivided, for the sake of clearness, into Mechanical Control and Chemical Control. The former covers certain agricultural practices, such as cultivation, rotation of crops, times of sowing and harvesting, which mostly apply to annual crops. Handpicking and trapping may also be included in this category. Traps are designed to take advantage of certain habits found amongst insects, or, as we might say, their responses to different forms of external stimuli. The sense of smell is well developed in most insects, and so we find many insects may be captured by means of baits. Thus, molasses and alcohol will attract certain moths and other insects. Destructive fruit flies may be lured to similar enticing liquids which are poisoned with arsenic. Light is well known to attract moths and beetles and is sometimes used for the purpose. In the vine-growing districts of Europe, light traps are extensively used. Those insects which climb trees may be captured by the use of sticky bands around the trunks. Cutworms can be diverted from seedlings by putting down damp bran, in which Paris green has been mixed. And so, by a study of the habits and activities of individual insects, some sort of trap can often be devised.

Chemical Control is applied to spraying, dusting and fumigation with poisons. There are a very large number of substances which are poisonous to insects. Vapours and gases are used for fumigating stored products, ships and houses for getting rid of pests attacking grains and the like, cockroaches, rats and other vermin. Spraying and dusting are used in the open; dust being used on large areas. There are two ways of killing insects by means of poison which depend on the structure of the insect. Caterpillars and beetles are provided with chewing mouth parts, so that if a leaf is covered with a layer of poison and such an insect eats it, the said insect will die.

There is, however, a large group of insects provided with a sucking proboscis. These are "bugs" in a restricted sense, examples of which are scale insects, paddy fly, the mosquito bug and the bed bug. These cannot be poisoned in this way. If one were to cover one's skin with an arsenic wash and allowed a mosquito to bite, it would take no harm. Against such insects as these it is necessary to use some substances which will attack them externally. Such things are soap, paraffin and some plant alkaloids. Keating's powder, which "Kills Bugs, Fleas, Moths and Beetles" is one of these. The alkaloids include Nicotine, Pyrethrum, Derris and Tephrosin. The

latter is obtained from *Tephrosia Vogelii*. A couple of ounces of the green leaf of the last named mashed up in a gallon or so of water is a useful solution in which to bathe a dog, since the fleas are readily killed.

The spray to be used therefore depends on the nature of the insect; but it must also depend on the nature of the crops. It would scarcely be wise to spray tea with arsenic; if we could do so, Tortrix and Nettle Grub could be more easily dealt with. Neither can one use in this particular case the creosotes and tar oils which would give a strong flavour to the tea.

Nearly all the sprays, dusts and fumigants used only affect the active insect, that is to say, they have no effect on the eggs of insects. For this reason, they are sometimes supposed to be not very effective, since the eggs will hatch out untouched, and for this reason, again, a second application is often advisable.

A word may be added with regard to Mites. These little creatures are not insects, properly speaking. One characteristic of insects is that they have six legs, another is that they are often provided, in the adult state, with wings. They are nearer to the spiders in structure than to insects. As they differ in structure so they appear to differ in constitution, since most insecticides do not affect them as much as insects, but they are particularly susceptible to sulphur powder, which does not affect an insect. Hence, the standard remedy for Mites is sulphur, which may be applied as a dust, or in the form of a compound spray, such as lime-sulphur; but again, the eggs are not killed by this treatment, so that a second dose is recommended.

This is a brief review of some of the forms of control practised against plant pests. Many considerations call for investigation and it is only by a thorough study of the insect and its reactions to its environment that we can pick the right lines on which to carry on the enquiry.

## DISCUSSION.

**Mr. Carson-Parker** asked if the Director could say what it was proposed to do in the way of combating Nettle Grub. He submitted that this was not only a pest of Uva, but that it had been reported from other districts and he believed that when once established it never completely disappeared.

**Dr. Norris** in reply said that he could not usefully add anything to what had been said by the Chairman of the Board and himself at a recent meeting of the Passara P.A. The serious damage caused by the pest was fully recognised by the Institute and the Board had already agreed to increase the staff required for its investigation. Any delay in doing this was due simply and solely to the difficulty experienced in finding suitable accommodation in the Passara area where the work was being carried out.

**Mr. C. H. Callander** asked for information regarding *Calotermes militaris* and whether work on this pest was being carried out by the Institute or at Peradeniya.

**The Director** said that Mr. Jepson of the Department of Agriculture had made a special study of Termites and it had, therefore, seemed advantageous that work on this subject should continue to be carried out at Peradeniya.

# PROCEEDINGS OF THE SECOND DAY.

The chair was taken by the Hon'ble Mr. C. H. Z. Fernando, Chairman of the Low-Country Products' Association.

## CHAIRMAN'S ADDRESS.

Mr. Coombe and gentlemen, in the first place it is my duty to thank you for the honour you have done me in inviting me to preside over this session, although I myself am absolutely innocent of any scientific knowledge of the subjects which are to be discussed. That I have been asked to do so is, I feel, a compliment to the Low-Country Products' Association of which I am the Chairman, and one of the instances of the healthy co-operation that now exists and has existed for some time between the various bodies that are working for the welfare of Ceylon, the land we all love. There are further instances of this co-operation in the work of such Institutions as the Tea Research Board and the other two Boards which have been established in connection with the other two major industries, and I personally look upon these Boards as replicas of what all of us would wish Ceylon to be some day, a country with all pulling their weight together, irrespective of creed and without selfish interests, but in the interest of the whole community.

Yesterday was a red letter day in the history of the tea industry in Ceylon as we saw the completion of the framework of the Tea Research Institute. The country is proud of the Institute, of the unofficial Board of Management and of the distinguished scientific staff who control its activities. I was pleased to note from the report of Dr. Norris's speech in last night's "Times of Ceylon," that it is the intention of the Institute to start sub-stations in other parts of the country, including the low-country. We, in the low-country, have watched with a great deal of care the prospects that now lie before us for low-country tea. We feel that the real future of the country lies in the low-country, owing to the fact that up-country is now practically opened up and the only land available is in the low-country and mid-country. We feel that something should be done to meet the successful competition of Java with low-country and mid-country teas. We feel that with the scientific work that is being carried on by the Tea Research Institute there should be a parallel scheme for the advertising of our tea in British and foreign markets. Unfortunately for us the Britisher is too modest by nature and is averse to blowing his trumpet, or advertising his wares. Nevertheless, in these modern days of strenuous competition modern methods of advertising must be resorted to.

On this memorable occasion we should not forget the pioneers who were responsible for the introduction of this Industry to Ceylon. When the coffee crash came those pioneers did not mope and sulk, but they brought the little capital they could find together and embarked on a new enterprise. Were it not for them the up-country of Ceylon would today be a howling wilderness and, instead of being, as we are proud to call ourselves, the premier crown colony, our place on the map today would have been as important as that of the Windward Islands. I feel that the Planters' Association, or some such interested body, should write the history of those pioneers, which would make an epic for us to read. I remember I had several conversations with Mr. Federick Lewis, who is unfortunately no more, and he had gathered together much information of those who pioneered the Tea Industry of Ceylon.

I shall not stand between you and the papers which you are so interested to hear, and I shall now call upon Mr. Tubbs to read his paper.

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# SOME PHYSIOLOGICAL ASPECTS OF PRUNING.

F. R. TUBBS.

In my address to you today I shall confine myself to describing some of the effects of pruning upon the life of the tea bush, particularly upon the changes caused in the relations of its various organs to each other and in its internal organisation.

In common with all living plants, the tea bush is dependent upon the reception, storage and ultimate degradation of energy. Energy is absorbed by its leaves from the rays of the sun and is used in the building up of complex substances from simpler substances. The most important case is the primary formation of sugars from the elements carbon, hydrogen and oxygen. In this process energy is stored away, the store houses being the sugar, or more complex substances of similar constitution, of which starch may be taken as an example. The formation of sugars can only take place in the light, whereas they are continuously being broken up to provide energy for processes which cannot be carried on by the aid of sunlight.

Thus we may regard the tea bush as the difference between two opposing series of actions: one series absorbing and storing energy from the sun, and the other series using these supplies as sources of energy for processes involved in growth. This difference which we call the tea bush can be further divided into the structural framework and the energy reserves and chemicals which the plant can call on to enable it to recover from a treatment which drastically lowers its ability to absorb energy—such a treatment as pruning, for example.

The life of a tree can be divided into two phases. The first is known as the vegetative phase and it is in this period that growth takes the form of leaf and shoot production. In the second or reproductive phase, less leaves and shoots are produced, and the energy of the plant is turned to flower and seed production. The reduction in amount of flush and in the size of the shoots composing it is the first indication in the tea bush of the change from the vegetative phase to the reproductive phase. Flowers make their appearance and increase in quantity as this gradual alteration progresses. Cohen Stuart has concluded that flower production has little influence on the flushing of the tea bush in Java. It is probable that would be the case in the early part of the change only.

The change to reproductive activity has attracted considerable attention on the part of physiologists. The American school of horticulturists has paid much attention to the biochemical aspects of this question. From their work three theories have arisen: the first attributes reproductive activity to deficiency in nitrogen; and the second to a high reserve of carbohydrates such as sugar and starch. The third theory has gained most supporters. It suggests that the type of growth exhibited by the plant is strongly influenced by the ratio of carbohydrate to nitrogen within the plant. Vegetative growth has been found to be associated with a lower ratio of carbohydrate to nitrogen than in the case of reproductive growth. The work of Kraus and Kraybill is of interest in this connection. They found that a plant containing very low amounts of carbohydrates but plenty of nitrogen showed poor growth, but when larger amounts of carbohydrates were present vigorous production of shoots and leaves occurred. If the ratio of carbohydrates to nitrogen was still bigger, less vegetative growth occurred but reproductive activities started. If the ratio of these substances was still further increased, both flower production and shoot production were suppressed.

If this theory is accepted as applicable to the growth of the tea bush, "shutting up" at the end of a pruning cycle may be caused by either too low or too high a ratio of carbohydrate to nitrogen. If the cessation of growth is due to is being too low, resting will enable the bush to accumulate carbohydrates. If too high, application of nitrogen, or the removal of part of the leaf surface, might be suggested. Neither of these treatments would obviate pruning which is necessary to maintain the form and size of the plant. Pruning is the only method of remedying the rise of the plucking table and the irregularities which result from differences in the growth of the branches composing the bush.

After the bush has been pruned, its leaf area has been partially or entirely removed, and with it the capacity of the bush to absorb energy for use in the manufacture of carbohydrates. The number of

potential growing points has been reduced, while the balance between the activities of the roots and the stems has been destroyed. It is fortunate that the bush reacts to such treatment by restoring the *status quo*, if its resources are such as allow of it. How can the bush be assisted in its task? The obvious method is to reduce the size of the task set it, subject to the necessity of maintaining the requisite shape of the bush and of inducing a return to vegetative activity. In other words, substitute a mild prune for a severe one whenever possible.

The lightest form of pruning used in Ceylon, if plucking is excepted, is the cut across. In contrast to the normal type, the ratio of top to root is not reduced so drastically, while the leaves left on the bush obviate the danger of the plants being unable to recover in the case of a deficiency of carbohydrate reserves. Cut across bushes show a quicker return to active visible growth. They have been found to have given about four times the new shoot growth forty-five days after pruning as bushes clean pruned at the same level. This more rapid growth of new shoots is borne out by data obtained from estates practising the two forms of pruning. Figures 1, 2 and 3 illustrate yields from fields cut across and clean pruned. The original data and curves calculated from them are shown. The smooth curves in Figure 1, from data covering a portion of the pruning cycle only, supplied by an estate near Ratnapura, show this quicker return on the part of the cut across field. Figs. 2 and 3 are similar diagrams made from data from estates near Matale and Talawakelle respectively. They also illustrate this, but in these two cases a tendency is shown for the greater part of the yield in cut across fields to be produced in the early part of the cycle; which is also shown, but not so clearly, by the Ratnapura data. An estate near Balangoda has given yields similar to those from the Ratnapura estate. Both cases show less falling off on the part of the cut across field than the other two estates. It must be understood that far-reaching comparisons may not be drawn from such data as these but the differences found are supported by the fact that grape vines show a similar difference when lightly or severely pruned. This question of distribution of yield is obviously of importance and will be examined on St. Coombs. There is little doubt that cutting across increases the yield, but in comparing the two methods, experience of them in one's own district must be considered. Increasing the yield by curtailing the cut across cycle so as to eliminate the low-yielding period would probably be found to force the bush too much, and to reduce or destroy benefits resulting from a milder form of pruning. There is little doubt that climate will also be found to have a large bearing on the matter although data are lacking in this subject.

Fig. I.

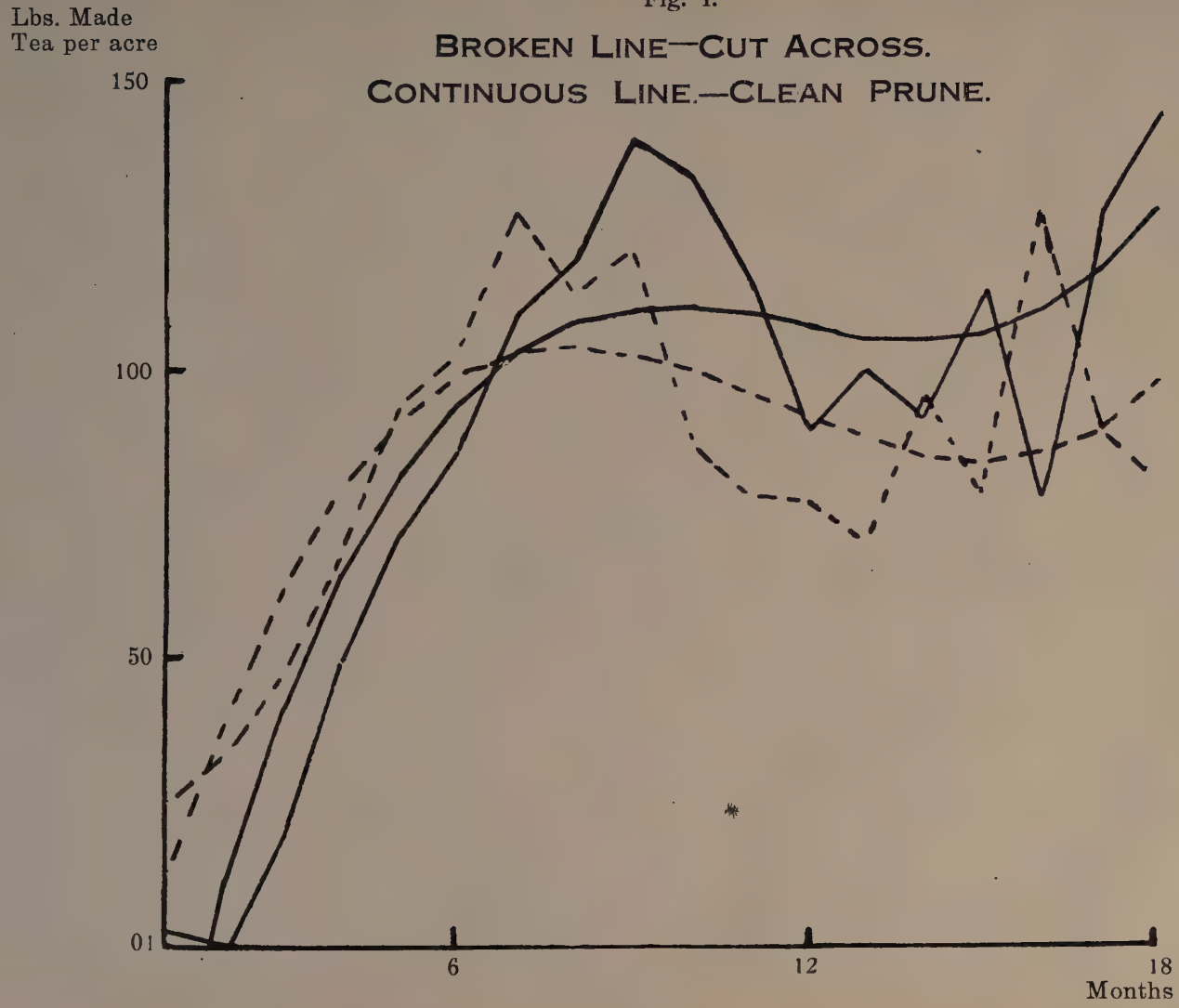

Lbs. Made
Tea per acre
BROKEN LINE—CUT ACROSS.
CONTINUOUS LINE.—CLEAN PRUNE.
150
100
50
01
6
12
18
Months

Fig. II.

BROKEN LINE—CUT ACROSS.
CONTINUOUS LINE.—CLEAN PRUNE.

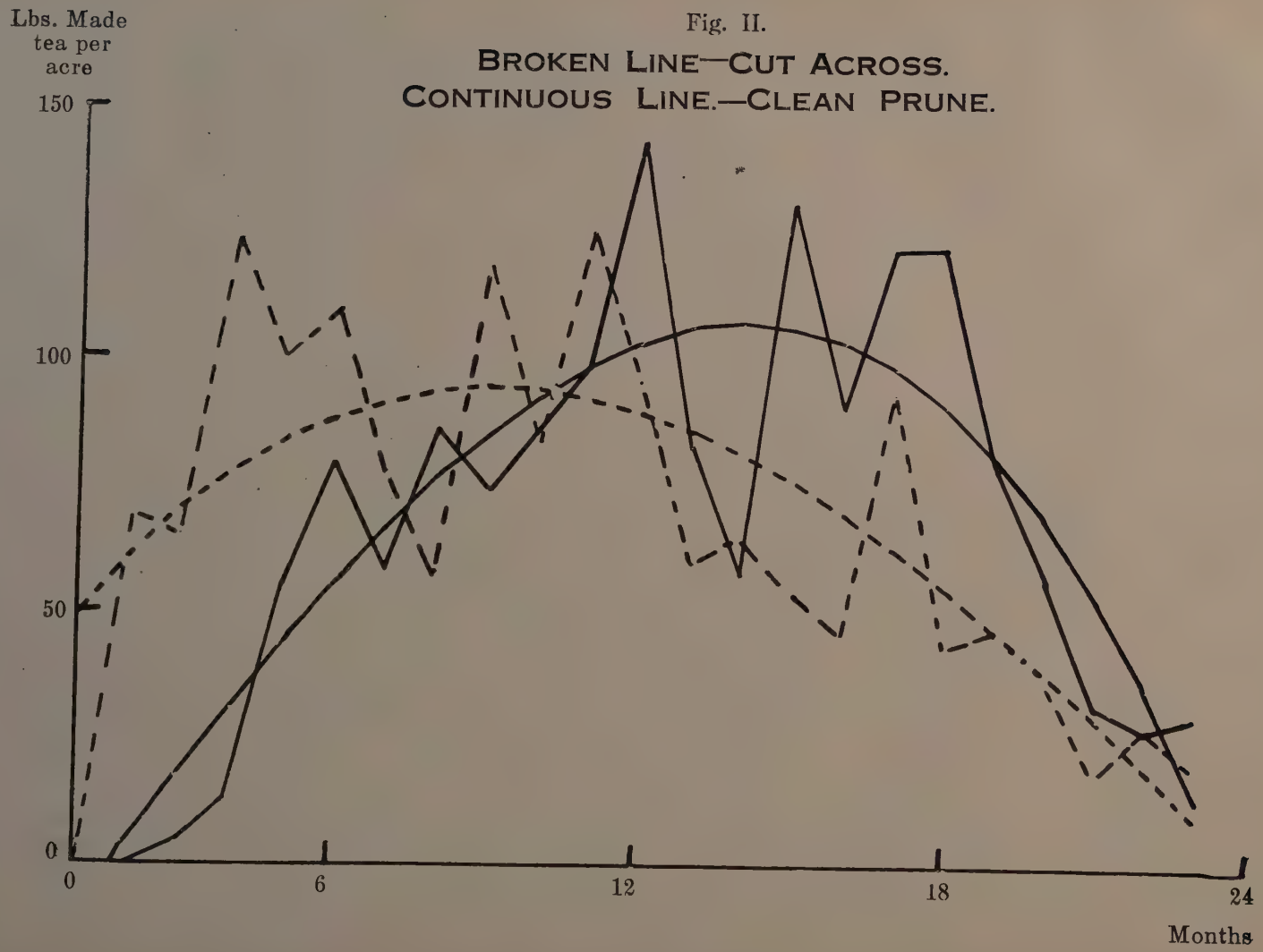
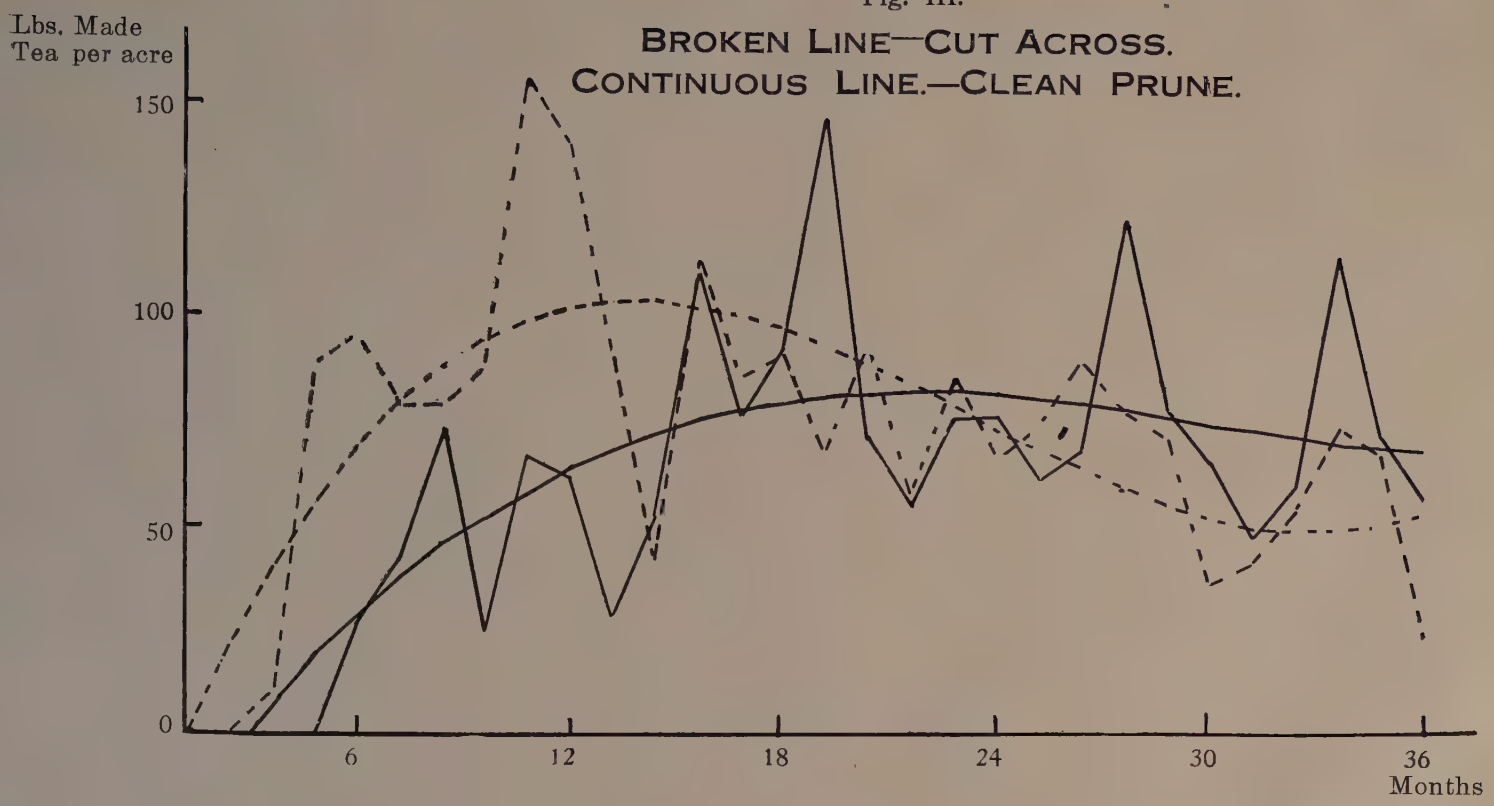


Fig. III.


BROKEN LINE—CUT ACROSS.
CONTINUOUS LINE.—CLEAN PRUNE.
Lbs. Made Tea per acre
150
100
50
0
6
12
18
24
30
36
Months

Cutting across is becoming increasingly common in Ceylon, especially since the connection between the severity of pruning and percentage of deaths after pruning in the low-country has been further elucidated by the Mycologist. One method is to alternate cutting across with normal pruning. This practice is being further modified by the insertion of several cut across cycles between normal prunings. The number that can be inserted is still a moot point, although adherents of the method can point to estates both in Ceylon and India on which continuous cutting across has been carried out for a large number of years.

A method used in India and described by Hope in a Tocklai Bulletin—the "Bagjan" method—was elaborated in order to obviate cutting down. The bush is cut across at the same level every time. After a time the branches become club headed, a few vigorous shoots being produced from each club, which form the basis of the cycle's plucking table. The less vigorous shoots die and often fall off later. If the formation of such clubs is to be avoided, a cut at a lower level is necessary occasionally, the frequency being dependent on elevation and the state of the bushes. This lower cut will result in the removal of nearly all the leaves of the bush, since the inside of the bush will have become nearly leafless. This effect of cutting across at a constant level is well known to anyone who has birdsnested in a quick hedge at home. Since such a lower cut will approximate to a clean prune in its effect upon the leaf area of the bush it may be made the opportunity for a "sanitary pruning."

Another factor concerned in the speed of recovery of a pruned bush is the age of the wood cut into. Data obtained at the Tocklai Experiment Station showed that when bushes pruned annually on one year wood were compared with bushes alternately cut across and pruned into two year wood, the beneficial effect on yield of the cut across treatment was almost removed by the cutting into older wood.

At present, we have little data concerning the drain upon the reserves of the tea bush when the new growth is produced after pruning, but we do know that deficiency leads to delay in recovery, or even inability to do so. It has been found in America that after the lucerne crop has been cut, new growth is initiated at the expense of the carbohydrate and nitrogen reserves of the root and that their amount controls the success and rapidity of recovery. Aldous showed that the best way of killing bushes in pasture land is to prune them severely when their reserves are least. The severe pruning of a so-called "Diplodia" field has an exactly similar effect.

Asami, working upon the Japanese Persimimon, carried out some interesting experiments upon pruning which illustrate that reserves are not the only factors affecting recovery from pruning. He found

that the percentage of the original branch which was removed in the act of pruning, was closely associated with the time taken to initiate new growth. The smaller the percentage removed, the quicker the return to active growth. A similar effect was noticed by Cohen Stuart in pruning experiments carried out on tea in Java. Asami attributed little importance to the effect of age of wood upon the recovery time, but experience with English fruit trees at East Malling has shown that the age of the wood cut has a definite influence upon the growth response.

There is little doubt that pruning reduces the new growth produced in a season by temperate trees. The more severe the pruning, the greater the reduction in new growth. It has also been found that the size of the roots of pruned bushes is smaller than in the case of the unpruned bushes, although there is no evidence that roots die back after branches have been pruned. Even such a mild operation as the pinching back of the feathery laterals upon the trunks of young standard trees—an operation that may be compared to plucking—has been found to reduce the size of the roots and the thickness of the main stem. Observations upon the effect of pruning or plucking upon the activity, rather than the amount, of the root system, appear to be lacking. It is probable that the activity of the root, with which is closely associated the amount of new fibrous root, may be found to be connected with the amount of top growth of the bush.

This has been but a brief summary of a subject that could easily be expanded to fill a large book. The tea bush is an organization of chemical elements in whose combinations energy is stored. Some of this energy is available for use in recovering from such a treatment as pruning until sufficient leaves have been formed to maintain growth and to replenish depleted reserves. As the age of an unpruned bush, or the time that has elapsed from pruning increases, it tends to turn from vegetative growth to reproductive growth. Pruning is resorted to in order to obviate this tendency and to maintain the bush in manageable dimensions. As a result of pruning, vegetative growth occurs whose vigour is dependent upon the food supplies available, the position of the pruned branches and the age of the pruned wood.

We need much more information upon the effects of different types of pruning upon yield and its variations within the pruning cycle, which may be still further traced into effects upon the shoots composing the flush, upon the reserves within the bush and upon the activities of the roots. Among such questions as these, we find others, such as the phenomenon of bhanjy, needing attention. Just as the manager of a large works must be always seeking new methods of increasing the efficiency of his factory, so must we take all steps possible to increase the efficiency of the tea bush.

# THE PRUNING OF TEA IN RELATION TO DISEASE.

DR. C. H. GADD.

The pruning of a tree is, in horticulture, the equivalent of a surgical operation in medical science. A surgical operation, however, is usually performed primarily to benefit the patient's health, often to save his life. The corresponding operation in horticulture is carried out for grosser purposes; yet, if the maximum benefits are to be derived from it, some consideration of its effects on the general welfare of the tree itself is essential. Before advising a major operation, a doctor would or should first satisfy himself that the operation is necessary; that the patient's health is such that there is a fair chance of his surviving the operation; that the operation is performed under the best possible conditions, and that the best available surgeon is retained for the work. It may be of interest to ascertain to what extent such principles can be applied to the pruning of a tea bush.

We may take it for granted that no planter will prune his bushes unnecessarily. Pruning is a necessary evil, and no one is better aware of that fact than the planter himself. If health were the only consideration, the bush would not be pruned other than to remove diseased or useless branches. The primary consideration, however, is crop, consequently, pruning is carried out with that aim in view. But if pruning is going to lead to losses as a result of the deaths of complete bushes or even of main branches, the main object will be defeated.

That being the case, the health of the bushes at the time of pruning should be such that they have a fair chance of surviving the operation. If health and vitality were measurable as physical quantities, the solution of many biological problems would be considerably advanced, and it would be possible to ascertain whether a tea bush was in a fit state for pruning. At present, health and vigour cannot be measured with any degree of accuracy so we must depend upon observation and experience for criteria. It is a common experience in the low-country to find that bushes which appear vigorous and healthy before pruning fail to make any growth afterwards. That is called the Diplodia disease. The deaths are not due primarily to the attacks of Diplodia or any other fungus; they are the consequence of an insufficient reserve of internal food material. A rest of about two months before pruning would probably enable the bushes to accumulate sufficient reserves to ensure an effective recovery after pruning. The recommendation to rest bushes for such a period raises the question "Is it economical?" The answer must depend upon the

particular case and the state of the bushes. On most up-country estates a rest is not necessary, but in the low-country a rest is in most cases advisable, particularly if "clean pruning" is practised. Where estates are restricting crop, resting the fields about to be pruned probably constitutes one of the best and most economical forms of restriction.

I do not propose to speak at length on the so-called Diplodia disease today. It formed the main topic of my address to you at our First Conference in 1929. I make reference to that disease here mainly as an illustration of what I mean by the bushes having a fair chance of recovery from pruning. Whatever else may be necessary, if the bushes are to be deprived of all or practically all their leaves, they must have an ample supply of internal reserves if they are to survive the operation.

Turning now to the operation itself and the conditions favourable to success, much attention is paid in a hospital operating theatre to its aseptic state. Fortunately, in tree surgery equal protection against pathogenic infection which would militate against success is neither necessary nor possible in a tea field. Through there is less risk of infection at the time of operation, this advantage is somewhat nullified by the fact that the wounds take longer to heal, and so there is a longer period in which infection may occur. The complete healing of wounds is as necessary in the vegetable kingdom as it is in the animal world. In the past very little attention was given to the healing of pruning cuts in a tea bush; it was sufficient to cut off the branch and let the wound take care of itself. The result can be seen in the majority of old tea bushes in Ceylon. Today more attention is paid to the question of healing, and more notice is taken of callus formation.

Healing is a process of growth, and consequently is correlated with general health and vigour. But all wounds will not heal equally well; much depends upon the position of the wound. As a general rule it is safe to say that the closer a wound is made to a growing bud or branch the more readily does the wound heal. In other words, a primary rule in pruning is to leave no pegs. This, to many, may sound like heresy, but in my opinion, the old practice of leaving pegs is fundamentally unsound. If a branch is to be removed it should be cut off flush with the parent stem; if a stem is to be cut back it should be cut close to an eye (bud).

The callus, which should ultimately, completely cover and seal the wound, arises from a small zone near the perimeter and grows inwards towards the centre of the wound. Consequently, the larger the wound the longer the time which elapses before it can be healed.

The callus of tea is slow growing, and some protection against infection by wood-rooting organisms is necessary wherever large wounds are made. The mere fact that callus growth has started affords no protection to the wood yet uncovered. Nor will the presence of a complete callus over a wound stop the decay of the wood beneath it, if that wood has been infected by a wood-rotting fungus before the wound was completely healed. I have isolated from the decaying wood of a tea bush, at a point below a wound which had been completely healed over, a fungus, which on test proved to be an active destroyer of tea wood. Externally, the branch, including the callus, appeared perfectly healthy. The fungus could only have established itself in the wood before the wound was healed. It is to prevent such happening that an artificial protective covering is necessary. This may take the form of tar, tar and wax, white lead paint or a suitable proprietary mixture.

It has been ascertained that under temperate conditions the best time to prune trees is at the end of their dormant period, or in other words, just before their growing period. That rule probably holds good for tea. Tea, however, is an evergreen shrub and has no very fixed times of growth and dormancy. These depend upon weather conditions and will vary with the district.

In theory, one should not prune at the beginning of a dry spell, but in practice one sometimes does. That is for economic reasons which may demand that the maximum number of bushes are in bearing at the time climatic conditions are such as to give maximum crop. Most estates have determined by experiment the best time to prune and there is little need to say more about it here, other than to remind you that the best time for pruning, from an economic point of view, is not necessarily the best time from a pathological view-point. My job today is to emphasise the pathological side.

Amongst the other conditions favourable to success one must include severity of pruning. We know from experience that a biennial clean prune at low elevations frequently results in a relatively high proportion of deaths. I have earlier suggested that a suitable rest before pruning constitutes one way in which such deaths can be avoided. Another is by instituting a lighter form of pruning which leaves a fair proportion of green leaf on the bush. From what I have seen and heard, the growing practice of light pruning is having a marked effect in decreasing the number of deaths following pruning. The popular form of light pruning is the "cut across." Cutting across, however, has its accompanying problems and evils.

There is the bhangi problem amongst others, but I am more chiefly concerned here with pathological problems. Whatever disadvantages clean pruning may have, it enables the bushes to be

thoroughly cleaned. The whole frame is exposed; rotten cavities in the frame can be cleaned out and treated; diseased branches are removed, often before the symptoms of disease are noticeable. Cutting across does not allow of such thorough cleaning, and consequently stem diseases are likely to become more noticeable. The two I have in mind are Red Rust caused by the alga, *Cephaleuros parasiticus*, and the true branch canker caused by *Macrophoma theicola*. I do not suggest that these diseases are bound to occur as a result of cutting across; what I suggest is that in fields liable to these diseases, they will become more prominent as a result of cutting across, because branches in an early stage of attack are not removed by normal pruning. It is possible for some such reason that the Indian Tea Association have for some time recommended the application of a fungicide after pruning.

An increase of what one may term the minor stem diseases of tea is not sufficient to condemn cutting across, as in my opinion the advantages to be derived from such a light form of pruning outweighs its disadvantages, so far as I have seen them at present. It does, however, raise the question whether it is advisable in certain fields to continue cutting across more or less indefinitely without a periodic clean pruning. The interval between clean pruning will depend upon the condition of the frame and the amount of disease occurring on the branches. I recently saw some fields which were clean pruned every eighth year, the bushes being cut across in alternate years in the interval. The system appeared to be highly successful. As only one-eighth of the estate is clean pruned annually, more attention can be paid to the frames of the clean pruned bushes than is the case where clean pruning is the general routine practice. This system is worthy of consideration. Some fields may run for more than eight years, others less, between clean prunes—no hard-and-fast rule can be applied.

In general terms, light pruning is preferable to hard pruning, from the point of view of disease, but that does not mean that all hard pruning is necessarily bad. There are occasions when collar pruning is necessary, but in all such cases it is advisable to rest the bushes for a period before the operation.

Tea bushes up-country appear to withstand heavier pruning than bushes in the low-country. I am not sure that in all cases this difference is a result of internal food reserves. It may be partly a result of climatic conditions, but I am more inclined to the view that it is a question of jât, and that a high jât bush will not withstand such heavy pruning as a low jât bush, other conditions being equal.

And now a word on the Surgeon—the Tamil Cooly. He certainly has no academic qualifications; he knows little about the

anatomy or the physiology of a tea bush, and one commonly regards his intelligence as being not of the highest type. Yet in spite of all these handicaps, if the lack of a scientific degree may be regarded as a handicap, he carries out his job creditably and merits considerable praise. But it is not to be expected that he will treat every bush rightly according to its merits. He must work to simple rules; perhaps, that is why it is better for him to get his instructions from a planter than from a scientist. He is told to prune to a level or to make his cuts a certain distance above the last pruning cuts. The scientist may say 'Prune close to an eye or bud.' The latter may be theoretically more sound, but the former is more practical. For one thing, the cooly would probably not recognise the buds on much of the wood he prunes into, and if he could, his task would have to be considerably reduced if he had to make his cuts close to vigorous buds. On the other hand, if wounds are to heal readily they should be made near the buds and not at a distance from them.

Does healing matter ? I think so, if the frames of the bushes are to be preserved. An open wound is a danger whether it be on animal or tree. The rotting cavities so frequently seen in tea bushes are the direct results of infection through wounds—most frequently pruning wounds. The natural preventive against infection is healing—artificial covers are but a temporary measure.

I suggest that the best method of meeting this point is by means of a 'secondary' prune. A certain amount of dieback is to be expected after pruning—the amount will depend upon climatic or other conditions but a certain amount, taking a field as a whole, is almost certain to occur. Such diebacks are best pruned out early. In addition to cutting out diebacks the secondary pruners also remove all snags and pegs left by the original pruners, and make the cuts as close to growing shoots as is possible without injuring the shoots. The pruning cuts then would be in the best position for healing, and callus growth would be more frequently observed in the tea bush. I submit that this suggestion is not impracticable but it is not the work for an average pruner. It is work for the most skilled pruners. It can be done any time after the new shoots have started growth and before tipping. The secondary prune applies more to clean pruning than to cutting across.

In conclusion, I would point out that there can be no one method or type of pruning applicable to tea in all districts under all the varying conditions of climate and elevation. There are, however, certain principles which underlie the operation and which should be taken into consideration when deciding upon the pruning treatment of any field. I have here attempted to indicate a few of them. The pathological problems associated with pruning do not admit of

solution by curative treatment; prevention is the key word and I submit that closer attention to the principles I have outlined here, would do much to prevent the occurrence of unsightly cankers and eliminate many of the losses so commonly associated with pruning.

## DISCUSSION.

**Mr. John Horsfall,** in opening the discussion, said that they had listened to what he considered to be the two most interesting papers he had had the good fortune to hear in this country. The papers were most instructive and after listening to them, planters must have come to the conclusion that there was still something to learn about pruning. The papers certainly gave food for thought and for argument.

The question of 'recovery' had been studied to a very large extent in the low-country by progressive and thoughtful planters who had taken warning from the colossal number of casualties. There they had adopted a system of 'cut across' in various forms, and that system was now undoubtedly creeping up-country. Up-country, however, the conditions were rather different from those at lower elevations. Generally speaking, the low-country planter, to his misfortune, was unable to deal in much else but quantity. Up-country they strove for quality, and it may be that on this they would have to hang their hats in the present state of affairs.

He had no doubt of the efficacy of the cut across as regards recovery, but he wondered whether it was advisable up-country, because of its possible relations with the question of quality. Apparently, 'cutting across' altered the distribution of yield in the pruning cycle, but the scientists were not prepared to say what would be its effect on quality. Where quality was the main objective, cutting across might have disadvantages. It was generally held that real quality did not come in during the first year from pruning and it was arguable when it did come—perhaps the second, third or fourth year. If so, their pruning then had to last that period.

It appeared to him that a half-way house between the two methods, cutting across and clean pruning, was required, and possibly 'lung pruning' might prove the answer. The system of leaving 'lungs' or 'flags' was not new, but was a reversion to an old type of light pruning. One remembered the time when an 'umbrella' was left in the middle of the bush to help it to manufacture its carbohydrates. Further this lung method gave an opportunity of pruning to an outer eye. Pruning to an eye throughout would be costly as the pruner's task would have to be reduced to 50 or 60 bushes. The method he advocated was to leave the 'lung' with too much on in the way of leaf rather than with too little. The lung could easily be taken off later by the secondary pruners. With him the secondary prune was done by the tippers at a cost of about 6 to 8 coolies an acre, and the work became cheaper as the coolies became used to it. He had the 'flag' or 'lung' pruned back to an eye, which had sprouted. The length of the branch left might be rather long but the plucking table grew up to it and there was no dieback. If no eye developed he left the flag till next pruning time by which time it usually developed. He had noted that his system gave very good callus growth on the wounds.

A further advantage of this method of pruning was in its relation to pruning mixtures. He had discussed this question with Mr. P. A. Keiller as far as the dry zone was concerned. There they did the pruning in July, August and September, and he gathered that Mr. Keiller's original idea was to apply the pruning mixture in April or May in order to get the bush in good vigour before pruning. If one applied the mixture at pruning time or just after pruning when

the bush was barcheaded and left with no 'lungs,' how was the bush to make use of the mixture even if the nutrients were readily available ? It was an extraordinary difficult problem and the further one delved into it the more complex it became, but it seemed to him that 'lung' pruning got over that difficulty.

Since adopting lung pruning he had noticed a marked improvement in his 'so-called' Witches Broom patches, the disease having disappeared entirely from some. His losses from pruning were at one time alarming, but now they were negligible. He was not prepared to attribute this improvement solely to lung pruning as he had experimented with other treatments also. He had tried flowers of sulphur, sulphate of iron and individual manures as well as eliminating dry weather pruning. He would not deny that applications of potash and the elimination of dry weather pruning were also contributery causes of this improvement.

That brought him to the question of dry weather pruning. He had arrived at a stage extraordinarily near Dr. Gadd's suggestion to prune at the beginning of a growing period and not at the end of it. He had so diminished his acreage of dry weather pruning that not more than one seventh of the estate was pruned during the dry period, and as a result die-back was diminishing markedly. Complaints were sometimes made that this meant a sacrifice of flush during the best period of growth. That however was not his experience. He had now carried out this system in increasing percentages over five pruning cycles—not five years —and one could by five cycles more or less eliminate climatic and individual vagaries. His experience amply justified the change from dry to wet weather pruning and he had experienced no loss of crop.

Mr. Horsfall again referred to the value of the secondary prune and said that for the work he used a special very light knife. It was double handed but had only a two-inch blade. He had found this to be a very satisfactory tool.

In conclusion, he asked Dr. Gadd whether he had come to any conclusion regarding the best time to adopt a 'sanitary' prune.

**Dr. Gadd** replied, after ascertaining that the 'sanitary' prune was used to indicate the clean prune after successive 'cuts across,' that the best time would vary in the different districts. As a fundamental principle he wou'd select the beginning of a growing period when the sap was beginning to move rather than a time of dormancy. He would prefer wet weather to a drought.

**Mr. Huntley-Wilkinson** asked what were the gross yields from the fields normally pruned and cut across, on the estates discussed by Mr. Tubbs.

**Mr. Tubbs** replied that he regretted that the precise data were not in the conference hall at the time.

**Mr. Wilkinson** said that the cut across treatment on the Dimbula estate resulted in an increase of 300 lb. per acre above the previous cycle, which was normally pruned. A complication was introduced by the application of 16 tons per acre of cattle manure in the cut-across cycle extra to the manures it had received in the previous cycle.

**Mr. Tubbs** said that on examination of the manuring programme of the estates he had discussed, it appeared that the earlier development of the maximum yield in cut-across fields was an effect of the type of pruning, although manuring might emphasise or decrease the difference.

**Mr. Morford** asked whether in bringing young clearings into bearing it was better to centre as late as possible, since it had been stated that pruning decreased root growth. He further asked for details of the elevation of the estate quoted by Dr. Gadd.

**Mr. Tubbs** replied that it was not known whether root growth was on the whole retarded to a greater extent by gradual pruning or by a severe cutting.

**Mr. J. Horsfall** said that in his experience a gradual thumbnail pruning gave a shorter but thicker taproot.

**Dr. Cadd** said that he could not give the exact figures of the estate referred to, but the elevation was roughly about 2,000 feet. As regards leaving young plants in clearings as late as possible before centreing, he pointed out that this meant, as a rule, making the first cut on fairly thick wood. It was a common experience in the low-country to be able to push a walking stick for some distance down the centre of the main trunk of a tea bush owing to the rottenness of the wood. The origin of this wood rot could probably be traced to the centreing operation. Thumbnail pruning, while the plants were seedlings, tended to induce low branching and to some extent removed the necessity for centreing. He would like from the disease point of view to see heavy centreing cuts avoided. He advocated the application of the secondary prune to centreing so that the final cut was made close to a shooting bud. In that way adequate callus formation would be induced, and the risk of wood rot setting in from the first cut minimised.

**Mr. Carson-Parker** referred to a system of pruning in India in which the men do the first prune and the women the second. He asked if Mr. P. H. Carpenter could give further details of it and tell them about pruning in general in India.

**Mr. P. H. Carpenter**, (Chief Scientific Officer of the Indian Tea Association) said that a distinction must be made between the cases described by the readers of the papers and the North Indian practice, since in North India pruning was annual and confined to the non-growing period. In Assam, growth finished in November and there was a non-growing season during December, January and February when the bushes were dormant. Pruning was done during that period.

As regards the Bagjan pruning referred to by Mr. Tubbs one must bear in mind that it was an annual prune. He had never seen it successful when anything more than one year wood had to be cut. The method was to remove practically all the new growth of wood and this produced the effect of pollarding. It was simply a system of cutting away new wood, and its object was to avoid cutting back. It was not adopted as a general system in Northern India, but he had seen areas which had been Bagjan pruned for twenty years. The bushes were giving a steady crop but they had lost their sides and become narrow. They consisted mainly of great central upright stems with a large knob at the end. Their spread was inadequate and afforded little cover for the ground.

Reference had been made to pruning experiments at Tocklai. At the beginning of the experiments the areas which were pruned biennially gave considerably more crop than those which were pruned each year, but as time went on they no longer showed this advantage, and today the annual pruned plots gave higher yields than those pruned biennially. This might have nothing to do with the actual time of pruning, as with a biennial prune older wood was being cut than was the case with an annual prune. They found that the wounds from a biennial prune did not heal quickly enough to prevent the introduction of disease spores into the wound, whereas the wounds made during annual pruning healed readily. For that reason annual pruning was preferred in Northern India, as this meant cutting on only twelve months old wood which healed rapidly. In this way they avoided the trouble which Dr. Gadd had warned them about that day.

With regard to the relationship between quality and pruning he was not in a position to say anything very definite except that the higher and longer the old wood was on the bush the slower was the growth and the better the quality. When they cut back and had vigorous new growth on the bush they lost quality. With collar pruning it was doubtful whether they got back the quality in under ten years; certainly not in under six.

The losses from heavy pruning, such as collar pruning were very great. It was not merely a question of immediate losses, which might be as severe as 40 per cent., but of the subsequent losses also. If a section were collar pruned or cut back to about twelve inches from the ground one might find on counting the deaths in that section over a ten-year period that at the end of that time the entire area had been replanted. The lighter the pruning, the better it was for the bush.

In conclusion, Mr. Carpenter said that he had to differ with Mr. Horsfall on one remark he had made. Mr. Horsfall had said that the papers they had listened to had given food for thought and food for argument. Mr. Carpenter agreed that they had provided food for thought but not food for argument.

**Mr. L. B. Green** asked whether nitrogen could be absorbed by the plant in the absence of foliage leaves.

**Mr. Tubbs** replied that there was no definite information on that point.

**Mr. Holland** recalled that an objection was raised to a proposed pruning experiment at Peradeniya on the ground that since yield was affected by many other cultural factors besides style of pruning, an experiment on pruning alone would be useless.

**Mr. Tubbs** replied that a very large number of factors were concerned in the growth of the bush, but that he did not agree that the investigation of the major factors should therefore be abandoned. An attempt to include even a fair proportion of the relevent factors in a field experiment on tea, if it were properly designed, would result in an experiment of a size that would be quite unmanageable. He referred to Mr. Eden's finding that 4½ acres a day was the limit of experimental plucking.

**Mr. Eden** confirmed this.

**Mr. Wilmot Perera** asked whether the forking in of prunings with the pruning mixture would enhance the danger of root rot, and whether the burial of pruning mixture with the prunings had any beneficial effect other than would be derived from the actual cultural operations applied separately.

**Dr. Cadd** replied that there was very little risk of root disease resulting from the burial of prunings if large wood was not buried. He would advocate the practice rather than condemn it, as the benefit to be derived from the incorporation of green material into the soil was immeasurably greater than the risk run from the introduction of disease by that operation, provided the larger and thicker wood was not included. He referred the second question to Mr. Eden, the Agricultural Chemist.

**Mr. Eden** replied that it was rather difficult to disentagle all the factors which were operating when a pruning mixture was applied and to differentiate with any great accuracy the effect of the forking alone, *i.e.*, the cultural operation, from the effect of the manure in providing nutrients for the bush except by careful experimentation. This question might well form the subject of later experimentation on St. Coombs. As regards the burial of a pruning mixture with the prunings, the former helped in the decomposition of the latter. The use of the two jointly was mutually beneficial.

# FACTORS IN TEA MANUFACTURE.

D. I. EVANS.

The process of black tea manufacture may appear to a casual observer as carried out to a great extent by rule of thumb, and a closer study of factory methods will divulge that, although details may vary, the general principles remain the same. The leaf is withered, rolled, fermented and fired in very much the same way on all estates, and yet the quality of the product varies in a manner which is not easy to explain. This difference in quality is due to a variety of factors, which must be borne in mind when considering any individual case. It would take us too long to discuss all the factors this morning and I should like just to mention some of these while dealing more fully with one or two which are of particular interest.

The first necessity for successful tea manufacture is sufficient space and machinery to deal with the crop produced in the heavy yielding months, an economical and rational lay out of the factory, and a staff of operatives as mechanically perfect in the routine of the factory as is possible. In spite of this there will still be differences in the quality of the product, and some of this difference must be attributed to the crop. This will vary with the jât of the bush, type of soil on which it grows, elevation, aspect, and climatic condition. Very little is known concerning the precise effect of these factors on the quality, except in general terms. Thus it is probable that elevation does affect the quality of the crop, but it is not clear whether this effect is due to altitude at such or because of the resulting temperature changes.

Apart from these more or less permanent factors tea is subject to seasonal variations produced by the change of weather, pruning, shade, and style of plucking adopted.

Another important factor in tea manufacture is the variation in crop produced. The yield may increase rapidly at certain periods of the year so that, unless this is taken into account when constructing the factory, the withering space may not be sufficient to deal properly with the crop at the rush period. There may be a shortage of machinery at the same time, and the quality of the crop will suffer. The crop at this heavy yielding period may not be so good in quality as the normal leaf, but the crop is so heavy that care taken to produce the best at this period is well repaid if only slight improvements are effected. The heaviest yielding periods should thus decide the size of the factory required.

This increase in the crop at certain periods involves more work per day in tea making. It is further complicated, however, by the fact that the rush months generally correspond with wet periods, and

not only is the weight of crop greater, but the work done per pound of tea turned out is also greater. This is very evident when the moisture relations during manufacture are considered.

| | Total weight of water evaporated Lb. | Wt. of water lost per lb. of tea. |
|---|---|---|
| February ... | 27,447 ... | 2·77 |
| May ... | 40,308 ... | 3·38 |

This loss of moisture is obtained in two different steps during the manufacture:—

(1) During withering
(2) During firing.

Much of the water associated with the leaf is due to surface moisture, and represents a weight of substance which has no real connection with the leaf. This means that this weight of water must be driven off before proper withering starts, and, in calculating the wither, the weight of withered leaf must be either referred to a smaller weight than that of the wet fresh leaf, or else the wither must be harder than is the case in the dry weather. The unevenness produced by wet leaf should thus be evened off during withering, so that the leaf taken for rolling contains very nearly the same amount of moisture every day. In this way uniform material is obtained for rolling, fermenting and drying, so that a good criterion of withering is the out-turn of fired tea on withered leaf. The greater moisture per pound of made tea thus involves more work on the leaf during withering. The range of variation in the moisture of the leaf coming into the factory is very high, the limits determined last year being 2·50 lb. and 4·60 lb. of water per pound of dry tea. It is, therefore, necessary at times to drive off as much water, or more, from the leaf in withering as would be evaporated during the whole process of tea making at other times.

Unfortunately the greater work involved in withering at this period has to be done under less favourable atmospheric conditions. It thus becomes necessary to prolong the wither, or else to take the leaf for rolling before it is properly withered. It is not always possible to keep the leaf in the factory until a proper wither is obtained, and it is not advisable to roll unwithered leaf, so that artificial methods have to be resorted to. Artificial methods of withering utilise slightly heated air in order to obtain a drier air, and this leads us to the consideration of the effect of heat on the leaf during manufacture.

When green leaf is steamed it loses its power to ferment and produce a coppery colour. Temperatures above 90°F cause the plucked shoot to turn red, the rate at which this reddening takes place

being dependent on the temperature. According to experiments carried out by the Scientific Department of the Indian Tea Association, leaf reddened in $3\frac{1}{2}$ hours at 115°F, and in 10 minutes at 138°F. This change must take place at lower temperatures but at slower rates. It is, however, easy to wither fresh leaf under Ceylon temperature conditions without any trace of red appearing, but certain conditions during plucking and transport tend to produce reddening unless this is carefully guarded against. Fresh leaf will not wither green in strong sunshine, but it becomes coloured in a very short time, so that undue exposure of plucked leaf to strong sunshine makes for red leaf. When the leaf is taken off the bush it is still living and respiring. This means production of heat energy in the mass of leaf in the plucking baskets. If this heat is not allowed to escape, high temperatures will be developed in the baskets and red leaf will result. According to the Indian investigators temperatures up to 140°F may be experienced in the middle of a plucking basket. I have not seen such high temperatures, but the leaf coming into the factory is invariably at a higher temperature than the atmosphere. With every precaution I have seen the leaf coming in recording 86°F, so that carelessly packed leaf can be at a much higher temperature than this. Actual reddening may not be visible, but nevertheless changes which make for red leaf and loss of quality will take place as a result of this heating. Great care should be taken in transporting the leaf into the factory at frequent intervals during the day, and it should be spread out as quickly as possible and not left lying about in heaps or in bags. The same strictures apply to the application of heat during withering, only that lower temperatures may have greater effects on the leaf because of the longer period it is allowed to act, and because the effect of heat is more pronounced on withered leaf than on fresh leaf. It is, therefore, advisable to maintain as cool conditions as possible during withering, and use discretion with the use of warm air. At lower elevations where temperatures are higher greater care still should be taken. The higher atmospheric temperatures, however, mean a greater efficiency in the drying capacity of the air, so that air conditioning by adding warm air need not be so drastic at lower elevations. Not only does temperature affect the leaf during transport and withering, but it is also an important factor during rolling and fermenting. According to Nanninga, who carried out experiments on fermentation many years, ago, fermentation should be carried out at 77°F, and H. H. Mann pointed out that a normal fermentation is obtained up to 82°F, but that when this temperature is exceeded a second reaction sets in, which results in the production of insoluble dark-brown products, followed by a loss of pungency, colour and body in the liquors. He also pointed out that temperatures up to 86°F have little effect on the production of aroma during

fermentation. Both of these investigators then agree that temperatures above 85-86°F are detrimental. More recent work carried out by Deuss in Java indicated a range between 68°F and 77°F as being the best for fermentation, and some factories in Java have described how they maintain their fermenting room temperature within this range.

These temperature conditions have been determined for leaf put out to ferment, but there is very little reference, if any, to the temperature conditions during the rolling process. It is now realised that fermentation takes place during rolling, in fact some of the leaf may complete its fermentation in the rollers. It is therefore necessary to consider the temperature conditions in the rollers, When this is done it will be found that fermentation is proceeding at high temperatures, very often well above the maximum allowed by Nanninga, Mann and Deuss. The rolling process should thus be watched very carefully if high temperature fermentation is to be avoided. Fortunately at high elevations the rolling room temperatures are low, so that a rise of temperature in the rollers can take place without exceeding the safety limit, but with higher rolling room temperatures it must be very difficult to keep the temperature of the leaf down below 86°F.

I am not propounding any new theory by saying that heat is developed in the rollers; you are all aware of that and the tendency to shorten the rolls, and to pay particular attention to the manipulation of the pressure cap, is due to the fact that experience has taught you it is necessary to avoid high temperatures in the rollers. I am not so sure, though, that it is realised that the heat produced is due to

(1) Friction in rolling the leaf.

(2) Heat generated as a result of fermentation of the leaf, and which would still be developed if there was not churning of the leaf in the rollers. This increase in temperature may be as much as 20-25°F even with careful rolling, but a casual observation of the leaf may give very little indication of this heating. Sometimes with careless rolling the leaf coming from the roller may be sensibly hot, and this is bad, but on the other hand the leaf may seem to be only just warm to the touch. Such leaf very often registers a temperature of 83-87°F. When the temperature of the rolling room is higher than this the roller temperatures are liable to be over 90°F which is well beyond the limit advocated. A certain amount of heating in the rollers does not always mean bad results, however; under certain conditions it improves the appearance of the infusion, but high temperatures as such are undoubtedly detrimental.

How is high temperature to be avoided? This can be done by a careful regulation of the pressure and the period of applying it. The effect of hard and light pressure on the temperature of the leaf coming from the rollers can be seen from the following figures:—

*Temperature increase of rolled leaf under different rolling conditions.*

| Roll. | Heavy Pressure | Light Pressure. |
|---|---|---|
| 1 ... | 21°F ... | 10°F |
| 2 ... | 21°F ... | 13°F |
| 3 ... | 22°F ... | 14·1°F |
| 4 ... | 19°F ... | 16°F |
| 5 ... | 16°F ... | 18°F |

Control of the presure applied will thus regulate the heat developed to a certain extent, and I understand that an attempt has been made recently to control the temperature of the leaf in the rollers by fitting cooling jackets to the rollers, but I have no information as to the degree of success obtained as a result of this. A cool rolling room of course is a first essential to cool rolling, and this can be obtained by means of humidification, which will be referred to later. Rapid cooling of the leaf coming from the rollers can be obtained by spreading the leaf mass immediately it comes from the rollers. Perhaps the effect of roll-breaking in cooling the leaf is not quite realised, but some idea of this can be obtained from the following data:—

| | °F. |
|---|---|
| Temperature of the leaf coming from the rollers ... | 84 |
| ,, ,, ,, ,, ,, at beginning of roll-breaking | 74 |
| ,, ,, ,, ,, ,, at end of roll-breaking ... | 70 |
| ,, ,, ,, atmosphere ... ... | 70 |

Leaf cooled in this way will thus start the next rolling period in as cool a condition as possible.

High temperatures are therefore bad for fermentation, but there is a certain amount of evidence that fermentation is difficult and uneven at low temperatures, though the limit of 68°F set by Deuss appears to be too high. Excellent results are obtained at lower temperatures than this, but the practice of returning the dhools to the roller shows that low temperatures are troublesome at times, and a warmer ferment is obtained by returning the dhools to the roller. The average temperature of fermentation of the separated dhools at St. Coombs is below 68°F, but this does not prove that better results would not be obtained between 68° and 77°F. The leaf which ferments in the rollers is doing this at a temperature varying between 75° and 86°F. Sometimes during the dry periods of the year the temperature of the leaf fermenting on the floor may be below 68°F, while the leaf in the rollers is fermenting at 75-80°F. It will thus be seen that in actual practice it is very difficult to say what is the temperature of fermentation. There is, then, a danger of too

cold a fermentation and the ideal conditions for rolling becomes detrimental for fermentation of the leaf removed from the rollers. This condition is not likely to arise at low elevations, but it is quite possible at high elevations where the rolling room temperatures may be very low. A cool temperature is required for rolling, but if the leaf separated is fermented in the same room the temperature may be too low for its fermentation. This raises the question "is the policy of fermenting in the rolling room a safe one"? The evidence seems to be against it, and it would appear to be better to have a separate fermenting room in which the temperature and humidity could be controlled to any desired extent.

Nanninga who was the first to investigate low temperature fermentation found the development of colour to be very slow, and that the aroma was much less pronounced at 57°F. It is possible, however, that temperature conditions affect the different reactions, which proceed during fermentation in different ways so that low temperature conditions may be beneficial for some and not for others.

Successful fermentation depends on the proper adjustment of the conditions so that most is made of all the reactions, and this cannot be attained until more is known concerning the reactions which take place.

The question of temperature of fermentation is closely connected with that of humidity. Bamber, Mann and others had pointed out that it was necessary to maintain a humid atmosphere in contact with the fermenting leaf, and Deuss found fermentation in a dry atmosphere resulted in uneven fermentation, and produced irregular infusions and dull liquors. The effect of a dry atmosphere is not corrected by turning over the leaf, since this practice only makes new surfaces for drying. Fermentation according to these investigators should be carried out in an atmosphere of 90-95% relative humidity, and cold dry draughts should not be allowed to play on the fermenting leaf. This is in agreement with practical experience, but observations made on the performance of a humidifying plant show that proper humidification means more than this. Fermenting leaf requires oxygen for the process so that the room in which fermentation is carried out should be well ventilated. It is possible to combine humidity with aeration and this is ensured in a plant such as exists on St. Coombs, where the volume of humid air supplied is sufficient to change the air of the rolling and fermenting room every 4-5 minutes. This ensures an ample supply of fresh air for the fermenting leaf and for the operatives.

The wet bulb temperature of the atmosphere is very low during the dry periods of the year, so that if humidification of the air can be obtained without increasing the wet bulb temperature in the process,

a cool room is ensured and this helps the rolling process considerably. A further advantage is also obtained because the rapid increase in temperature which takes place outside during the day is not experienced in a properly humidified rolling room, *i.e.*, a more uniform temperature is obtained throughout the day. This effect can be very well seen from the accompanying table where the gap between the outside and rolling room temperature gives some idea of the cooling effected.

*Cooling Effect of Humidification.*

| Rolling Room Temperature °F. | | | Outside Temperature °F. | | | Cooling |
|---|---|---|---|---|---|---|
| Dry | Wet | Difference | Dry | Wet | Difference | Effected °F. |
| 69 | 67 | 2 | 80 | 67 | 13 | 11 |
| 59 | 56 | 3 | 75 | 57 | 16 | 16 |
| 59 | 56 | 3 | 73 | 57 | 16 | 14 |

A further advantage of humidification is that it allows of thinner spreading of the fermenting leaf, which may be left to develop a full fermentation even during very dry periods. If no humidificatoin is resorted to the leaf dries up and blackens, and to avoid this it is spread thickly and very often taken to the dryers before it has had time to ferment properly.

Fermentation is initiated by the pressure exerted in the leaf during rolling, but it is more difficult to find out what actually happens in this process than in any other stage of manufacture. The obvious effect of rolling is that of cutting up the leaf which is of great importance for the later operation of grading. The shearing effect of rolling can be followed by weighing the dhools separated after each roll breaking. It is found that the greatest factor in the separation of dhools is the pressure applied in the rollers and the care given to roll breaking. An example of the difference in the separation of the dhools as a result of heavy and light rolling is given in the table.

*% Separation of Dhools.*

| Roll | Heavy Pressure. | | Light Pressure. | |
|---|---|---|---|---|
| 1. | 32·0 | 69·7% | 13·0 | 42·8% |
| 2. | 23·2 | | 14·9 | |
| 3. | 14·5 | | 14·9 | |
| 4. | 10·5 | | 19·7 | |
| 5. | 14·5 | | 25·0 | |
| B Bulk | 5·3 | | 12·5 | |

Although higher temperatures are obtained with heavy pressure than with light pressure, this is neutralised to a certain extent by the

removal of a greater portion of the leaf from the seat of high temperature to the cooler conditions of the fermenting room. In this way, 69·7% of the leaf being manufactured is fermenting in cool conditions after 3 rolls, as a result of heavy pressure, whereas only 42·8 per cent has been taken from the high temperature region in the same period with light rolling. The nett result of light rolling is thus a cooler maximum but a longer fermentation at the moderately high temperature. Temperature of fermentation in the roller can thus be controlled by means of the pressure applied to the leaf, but it must be borne in mind that a change in the pressure also means a change in the rate at which the leaf is fractionated out.

Under experimental conditions the shearing effect of the rolling can be examined more closely by actually sifting out the various sized particles in the rolled leaf at different periods during rolling, and estimating the amount of tip and stalk which separate out under different conditions, and by this I mean an actual count or weighing of the tip and stalks. Thus, in the case of the light and heavy rolling experiment previously referred to, light rolling separated 14·2 per cent of tip in the first roll, whereas heavy rolling only gave 9·2 per cent. Again, where light rolling finished up with a big bulk of 24 per cent stalk, heavy rolling finished up with a big bulk of 44 per cent stalk. The process can be followed further by determining the grades turned out, the number of cuts required and the yield of dust and pickings obtained as a result of the different treatments.

It is not possible to make such a careful survey of the rolling process in practice, but it is a simple matter to keep all the dhools separately and to weigh them before they are sorted. This will supply a good check on the conduct of the rolling operatives. It will be found that there is some variation from day to day as a result of variation in the nature of the leaf coming in, but after a time it is possible to gauge what margin of variation can be allowed for the leaf and what is really due to neglect on the part of the cooly. There is another advantage in keeping a record of the dhools, because it can be referred back to years later, if necessary, to see whether there has been any alteration in the manner of rolling in the course of time. This can be very useful to a new-comer to an estate, since he can gauge at once the type of rolling carried out by his predecessors.

These are a few of the factors concerned in tea manufacture, there are many others which I have not touched upon, to do so would be to keep us here indefinitely. These remarks will show that there are many points to be decided upon yet, but I hope this will not create a pessimistic outlook, as many problems which remain unsolved should yield to experience and research. Time, however, is an essential condition to success, and it can only be after months of research that there can be a sufficient supply of scientific data to enable positive conclusions to be reached.

## DISCUSSION.

**Mr. W. S. Burnett**, before proceeding to a discussion of the paper, said that he felt he was voicing the sentiments of all those present by expressing his appreciation of the very valuable paper read by Dr. Evans. He said that he, personally, thought that manufacture was more important than pruning, because it was possible that in the next few months their very livelihood would depend on the quality of the tea that they turned out. Mr. Burnett then read the following extract from a circular received from his Agents—"It is earnestly hoped by all traders that producers realise that the only possible solution of the difficulty is to concentrate all efforts on the production of the very finest tea which their estates are capable of. To effect this, attention should be devoted to fine plucking and the most careful manufacture—quality will quickly bring its own reward as proved by certain gardens and districts during the past season."

**Mr. J. E. B. Baillie-Hamilton** asked whether light played any part or not in fermentation and **Dr. Evans** replied that nothing has been done on this problem since Mann investigated it some years ago. Mann concluded that provided glare was avoided, then light had no effect on fermentation. This was a point which was being kept in mind and which would be inevstigated at St. Coombs.

**Mr. Orloff Coombe** asked why the fermentation of indifferent jâts of leaf appeared to be more rapid than that of good jâts.

**Dr. Evans** mentioned that he had already stated in the beginning of his paper that nothing was known concerning the effect of jât, climate, etc., on quality. He pointed out that it had been impossible to investigate problems of this nature in the short period they had been at St. Coombs.

**Mr. Bruce Foote**, referring to the table giving the increase in temperature of the leaf in the rollers, asked why the temperature of the leaf in successive rolls under heavy pressure diminished, whereas under light rolling conditions this increase of temperature became more and more pronounced.

**Dr. Evans** agreed that the condition found appeared, at first sight, to be somewhat strange but the effect observed as a result of heavy rolling was due to the fact that strong fermentation was set going in a great mass of leaf in the *early* stages. The mass of the leaf remaining in the rollers was also greatly reduced with heavy rolling, so that the actual amount of fermenting leaf producing heat would be comparatively small in the last rolls and the ratio of surface to mass exposed to the cooling effect of the air would be sufficient to allow of keeping the leaf cool. With light rolling, on the other hand, the production of fermentation in the leaf must be a gradual one, increasing steadily as the pressure was increased. The mass of leaf, however, was not reduced so rapidly as with heavy rolling so that this resulted in an increased fermentation of a large quantity of leaf, which would not cool so rapidly on rolling as the comparatively small bulk left with heavy rolling.

**Mr. Orloff Coombe** pointed out that leaf was usually spread about one inch thick for fermenting, and it seemed to him that under such conditions the only leaf which came in contact with the atmosphere was that in the top layer. Why was it necessary for correct fermentation of tea to change the atmosphere every four or five minutes, was the action chemical or physical ? The speaker had carried out factory experiments himself on the question of aeration of the leaf during fermentation, but did not find any difference in the tea produced with leaf given plenty of oxygen from leaf which had been covered with a box so as to exclude entry of air.

**Dr. Evans** replied that a greater oxidation must occur at the surface than in the body of the fermenting leaf mass, but that with thin spreading a certain amount of air permeated into the leaf mass. He said that there

was a certain amount of misapprehension concerning the question of ventilation in the rolling and fermenting room. The necessity for a change of air every four or five minutes was due not so much for supplying fresh oxygen, but because of the heat developed in the rolling and fermenting room. Heat was generated in the rolling room by the fermenting leaf, the moving machinery, the operatives and by radiation from the walls. This heat developed was countered by blowing cold, humid air into the room, so that the volume of cold air admitted into the room must be sufficient to overcome this heating effect. This can only be obtained by a fairly rapid change of the air in the room.

**Mr. H. C. Carmichael** said that they heard much about perfect withers, perfect rolling and perfect fermentation, but he would like to know something about the end of manufacture—firing. He would like to know whether anything had been discovered as to the correct method of firing, and whether quality of flavour was lost up the chimney in the process of firing.

**Dr. Evans** replied that quality and flavour might be lost in the firing process but the proper conditions of firing had not been determined. Some people preferred a high temperature and others persisted in maintaining as low a temperature as possible, but no investigations had been carried out by him on his point.

**Mr. J. Horsfall** said that Dr. Evans had suggested that certain figures be kept in the factory for reference, and he would like to suggest that any Superintendent who adopted this practice would have to be very careful of the teamaker who would soon know "what master liked to see." He, therefore, recommended planters to be careful to adopt their own particular systems of checking the correctness of these figures.

Mr. Horsfall, commenting further on the paper, stated that the figures relating to the percentage tip separated in light and heavy rolling did not necessarily show that heavy rolling resulted in loss of tip, since the percentage tip isolated in the dhool would be less on account of the greater bulk of leaf sifted out. Concluding, he stated that he wishesd to congratulate Dr. Evans on his excellent pamphlet entitled "A Handbook of Factory Information."

**Dr. Norris** announced that copies of this pamphlet would be available to members who desired to have them after the meeting.

**Mr. E. C. Marsh Smith** in a letter read by Dr. Evans said that it was very generally understood now amongst planters that faults in rolling, fermenting, firing, and sifting could easily be traced (or comparatively so) especially from brokers' remarks on samples. But when the faulty, or rather unsatisfactory manufacture, pointed to wither, it was difficult to know whether it was wither alone or wither combined with fermentation. Plenty of conditioned air, or a natural wither with open windows, had always been spoken of as being a basic condition of good wither, but, lately, owing to the success of certain factories in getting high prices, opinion seemed to be veering the other way, and slow natural withers, even if windows had to be kept shut, were preferred to quicker withers by the use of fans, however well-conditioned the air. He knew of one factory where, by slowing down the wither in dry weather and keeping out the damp winds during wet weather, prices had improved enormously. In two other factories where prices were always exceptionally good, the leaf was not even spread thinly and withers were allowed 36 and 48 hours. Did that mean that in the case of quick withers, physical wither was completed before the chemical, in that better prices were procured for the slow withered teas ? These teas were thicker and stronger in liquor. If one could leave the leaf to wither any length of time without artificial aids such as fans and get better results, he failed to see the object of the Commercial Co.'s system. Those factories where slow withers (often with windows shut)

were the practice got uniform and even withers because one end of the loft was not subject to a rapid stream of air, while the far end was under air practically stagnant by comparison, speeds often dropping 50 or 60 per cent. over the length of the loft. Did it all come to this ? Slow hard withers gave a soft even leaf, easily broken up by rolling, while hard withers, by opening windows or by artificial means hardened the surface of the leaf and left the inside not withered or only partially so?

Personally, he got thin liquors every time a hard wither was attempted. If a longer ferment was tried to counteract this, then the infused leaf was inclined to be duller. He asked if pressure applied from the early rolls counteracted thinness of liquors. With hard withering he got a lot of buds blackened like fired tea and the dust grade increased.

**Dr. Evans** agreed that undoubted success was being obtained in certain parts of the country by means of very slow withers. He knew of instances where by adopting a policy of slow wither, or by extending the withering period by piling the leaf on the tat to prevent too quick a wither, a beneficial effect had been produced in the teas marketed. It was claimed that such a policy resulted in giving the tea a particular characteristic demanded by the market, whereas a quick wither resulted in a plain, uninteresting tea. Such success, however, depended to a certain extent on the possibility of having sufficient withering space for the leaf to be kept in the factory for the necessary length of time. If this could not be done and a wither was not obtained in 18-24 hours, it was necessary to use warm air, and under such conditions it was advisable to avail oneself of a system which would provide the hot air with the least possible trouble. The faults ascribed to artificial withering could very often be traced down to the indiscriminate use of hot air.

The investigation of the relative merits of a long wither as against a short wither was one of the basic problems of research in tea manufacture, and this question formed one item in the programme of work drawn up. It would be premature to form any conclusions until the work had been completed, but he assured the meeting that the investigation of this problem would be approached with an open mind, and the results obtained would be impartially reported. In the meantime, Dr. Evans stated that he would be most pleased to hear something about the experience of planters who advocated a long wither, since he could see present many people who practised this system.

**Mr. C. Horsfall** said that his experience was that if he worked with a quick wither, a nice supple leaf was not obtained. He was, therefore, forced to adopt the policy of slow withering, and he thought that this was characteristic of the jât of leaf he had to deal with. He also had the same trouble with the blackening of the tips during a quick wither as Mr. Marsh Smith, but he would still prefer a quicker wither if he could get a supple leaf as a result of it.

**Dr. Evans** also pointed out that it was not possible to keep the leaf on the tats indefinitely, especially in the low-country, since decomposition of the leaf was liable to set in. It might be possible to keep it for fairly long periods at high elevations where the temperatures were low, and the decomposition did not proceed at a very rapid pace, but at low elevations this decomposition took place very rapidly, and, unless care was taken to wither the leaf in good time, the teas would suffer as a result of this putrefaction.

## TRIBUTE TO MR. R. G. COOMBE.

Mr. L. A. Wright said that before the meeting broke up he would crave permission on behalf of himself and his fellow-planters to express their great admiration and warm gratitude to Mr. R. G. Coombe, who was the prime mover in the establishment of the Tea Research Institute, on the success that had attended the Conference. While expressing their thanks to Mr. Coombe he would like to associate with him the Committee and the others who had helped him—he referred to Dr. Norris and the Scientific Staff—for their valued co-operation and help in achieving that success. He felt it difficult to express his admiration of all that he had seen on the occasion of this visit to St. Coombs. The day before, the Acting Governor in his opening remarks had emphasised the enormous amount of forethought and care which had been exercised and lavished on the scheme. He would like for his own part heartily to endorse what His Excellency had said. He was sure that they all realised the untiring efforts of Mr. Coombe, who, in spite of his being a busy man, had given generously of his time to the planting community, and on this the First Conference to be held at the Headquarters of the Tea Research Institute, he felt that it must be a proud moment to Mr. Coombe to look around and see the way in which his fellow-planters had marked their appreciation of his efforts.

Mr. R. G. Coombe, said that, before asking the Chairman to close the Conference, he would like to assure Mr. Wright that he very greatly appreciated the kind remarks he had made with regard to the work he had done for the Tea Research Institute. His task, Mr. Coombe said, had been a hard one, but it was a pleasant one inasmuch as he had been surrounded by a really hard-working and painstaking Board whose work, however, would not have been easy but for the assistance they had received from the very loyal and hard-working staff.

There was first of all Mr. Petch, who undoubtedly laid the groundwork. But the work that had been done by Dr. Norris since he came to Ceylon was realised by no one more than by him and the Board. Dr. Norris had made the work of the Board extremely easy. As he had said at the previous Conference he would repeat that, given time and opportunity, the Institute would justify its existence. Dr. Norris had told them the day before that a good deal of research work was long range work, which meant that it would be a long time before an opinion could be given on many of the problems now being investigated. Scientists were very reluctant to express an opinion until they were certain of their facts. He would therefore claim their

indulgence in regard to the work which was being carried on at St. Coombs. He would like, therefore, to emphasise what Dr. Norris had said and ask them to be patient. The Institute would undoubtedly more than justify its existence, but the support the planting community had given them that day—he was sure he was voicing Dr. Norris's sentiments too—was most encouraging. The attendance of planters was a compliment. The work which they had begun at St. Coombs could be carried on only with the hearty co-operation of the planting community of the Island.

Mr. Gordon Pyper said that they should not forget the name of one other gentleman who had first broached the subject of tea research, Mr. C. C. du Pré Moore, who, when he was the Chairman of the Matale Planters' Association, was the first to advance the idea. Mr. du Pré Moore's name should be remembered and included amongst those to whom they gave praise.

The Chairman said before closing the Conference he would like to associate himself with what fell from Mr. Wright in regard to Mr. Coombe. He remembered that, when in Select Committee in connexion with another Scheme, they were considering the question of appointing an unofficial Chairman instead of an official, it was pointed out by another member that it would be impossible to duplicate Mr. R. G. Coombe—it would be impossible to get another man who would work with the same energy as Mr. Coombe in connection with the Tea Research Institute.

Mr. Fernando said he was reminded of the words in St. Paul's Cathedral, in reference to Sir Christopher Wren: His monument is here. So if they were looking out for a monument for Mr. Coombe they would only have to look round that institution with its magnificent buildings.

The Conference was then declared closed, the afternoon being left free for visitors to inspect the factory and estate.

# MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON.

A meeting of the Board of the Tea Research Institute of Ceylon was held in the Grand Oriental Hotel, Colombo on Thursday, 29th January, 1931, at 11-15 a.m.

*Present*:—Mr. R. G. Coombe (Chairman), the Hon. the Colonial Treasurer, the Director of Agriculture, the Hon. Mr. D. S. Senanayeke, Mr. A. G. Baynham (Chairman, P. A. of Ceylon), Major J. W. Oldfield, Major H. Scoble Nicholson, Messrs. J. D. Finch Noyes, John Horsfall, T. B. Panabokke, R. R. Muras (Assistant Secretary), A. W. L. Turner (Secretary); and by invitation Dr. R. V. Norris (Director, T. R. I.), and Mr. J. Carson-Parker (Chairman, Uva P.A.).

*Absent*.—Messsrs. F. F. Roe and Jas Forbes (Jnr.).

1. Notice calling the meeting was read.

Before proceeding with the business of the Meeting, the Chairman referred to the death of Mr. A. O. Whiting, who was Secretary of the Ceylon Association in London and had done a great deal of work on behalf of the Institute.

A vote of condolence was recorded.

2. Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon, held on 1st October, 1930, and of the Joint Meeting of the Finance Sub-Committee, Estate Sub-Committee and Experimental Sub-Committee held on the 22nd November, 1930, were taken as read and confirmed.

### 3. FINANCE.

(a) *Statement of Accounts as at 31st December, 1930*.—The Chairman explained that the Statement of Accounts as at 31st December, 1930, which had been sent to all members of the Board on the 24th January, 1931, was not the final statement for the year, and a supplementary account would therefore be issued later.

It was decided that a depreciation account be openend forthwith and an annual allowance of 10% on Machinery and 5% on Buildings credited thereto.

The Accounts were passed without further comment.

(b) *Tea Cess*.—The Chairman announced that the increase in the Tea Cess was published in the "Government Gazette" on the 14th November, 1930.

(c) *Estimates for 1931*.—After discussion and some amendments the Estimates for 1931 were unanimously approved by the Board.

(d) *Travelling Expenses.*—It was decided that the new Government rates should apply to the travelling expenses of members of the Board and Scientific Staff from the 1st January, 1931.

### 4. MEMBERS OF THE BOARD.

Votes of thanks to Messrs. G. R. Whitby and D. S. Cameron for their services as members of the Board were recorded.

### 5. ST. COOMBS ESTATE.

(a) *Laboratories of the T. R. I.*—The Chairman announced that the new Laboratories at St. Coombs Estate were occupied by the Staff on the 15th December, 1930.

(b) *Bungalows.*—The Chairman announced that 4 each of the bungalows for the members of the Senior and Junior Scientific Staff were now being occupied. A further two junior bungalows would be shortly completed and ready for occupation.

(c) *Teas for the London Market.*—Referring to the Resolution passed at the last Meeting, the Chairman said that the samples of teas had been sent to London. These had been submitted to nine London Firms for valuation and report. Very satisfactory reports had recently been received, indicating that the teas were suitable for the Home Trade requirements.

### 6. SENIOR SCIENTIFIC STAFF.

(a) *Entomologist.*—The Board confirmed the increment due to this officer as from the 9th December, 1930, which had been sanctioned by the Chairman.

(b) *Biochemist.*—Reported that Dr. Evans' leave would take effect as from the 11th March, 1931.

(c) *Mycologist.*—An application from Dr. Gadd for three months' vacation leave from Ceylon on urgent personal affairs was sanctioned.

(d) *Agricultural Chemist.*—This officer's application for nine-and-half months' leave from 30th December, 1931, was sanctioned.

### 7. JUNIOR STAFF OF THE T. R. I.

The following appointments were announced:—

(a) *Research Assistant, Agricultural Division.*—Mr. C. A. de Silva, B.Sc.

(b) *Field Assistant to the Agricultural Chemist.*—Mr. M. Piyasena.

(c) *Junior Assistant, Department of Physiology.*—Mr. O. J. Welaratne.

(d) *Provident Fund.*—On the proposal of tht Hon'ble the Colonial Treasurer the amended rules for the Provident Fund for the Subordinate Staff were adopted.

## 8. SUB-COMMITTEES.

The Chairman explained that at present there were:—

(a) Finance Sub-Committee.
(b) Experimental Sub-Committee.
(c) Estate Sub-Committee.

He suggested that the Experimental and Estate Sub-Committees should be amalgamated and designated the Experimental and Estate Sub-Committee.

This was agreed to.

The following were elected to serve on these Sub-Committees:—

*Finance Sub-Committee.*—The Chairman, T. R. I., Chairman P. A. of Ceylon, Chairman, C. E. P. A., and Director, T. R. I.

*Experimental and Estate Sub-Committee.*—The Chairman, T. R. I., Director, T. R. I., Agriculturist Chemist, T. R. I., Visiting Agent, the Superintendent of St. Coombs, Messrs. John Horsfall and Huntley-Wilkinson.

## 9. NETTLE GRUB.

The Chairman reported that as a result of reports received of the marked increase of this pest in the Passara District he had visited the estate, where the pest was most prevalent, with the Director and the Entomologist. As a result of this visit he considered it imperative that further arrangements should, if possible, be made to cope with the pest.

The Director mentioned that though the estate referred to by the Chairman had provided a bungalow for Mr. Austin it was not big enough if the work were to continue for any length of time. Further accommodation would be required for the Laboratory and Insectary and also for the additional Staff, it was hoped to provide for this work. These additions would be capital expenditure and it was a question whether the Institute should bear the cost.

The Chairman proposed that the Institute should not undertake any capital expenditure with reference to this and similar investigations but would be quite willing to provide the necessary Scientific Staff. This was agreed to.

## 10. TERMITES.

The Chairman stated that he had been informed that Dr. Snyder from the U.S.A. had been engaged to investigate Termites in India. He considered that an effort should be made to get Dr. Snyder to visit Ceylon officially as well.

It was decided to circulate the papers in this connection to the members of the Board for their views thereon.

## 11. ANNUAL REPORT, 1930.

The Secretary's portion of the Annual Report was adopted.

A. W. L. TURNER,
*Secretary.*

# NOTICES.

The Institute's laboratories are situated at St. Coombs, Talawakelle, and all applications and enquiries should be addressed to the Director, Tea Research Institute, St. Coombs, Talawakelle.

Specimens and other consignments sent by rail should be forwarded to Talawakelle Station, c/o. Messrs. Hemachandra & Co., Forwarding Agents.

*Visitors' Day.*—The first Wednesday in each month has been set aside as Visitors' Day at St. Coombs Estate, when it is hoped anyone interested will visit the Station.

Visitors at other times are welcome but the Staff may not be free to show them round. Such visitors on arrival at the Factory are requested to ask for the Teamaker.

St. Coombs Estate is reached by taking the turn-off opposite culvert marked 28/10 on the Nanuoya-Talawakelle main road. A signpost has been erected at the turn-off.

*Publications.*—Applications for the Institute's publications should be directed to the Secretary, at Victoria Commemoration Buildings, Kandy, and *not* to the Director's Office.

ROLAND V. NORRIS,
*Director.*

# EDITORIAL.

## MANUFACTURE.

The depressed state of the market during the current year and the consequent more insistent demand for well-made teas has resulted in considerably more attention being paid to manufacture. This has been reflected in the very large number of enquiries which have been received by the Institute for information and advice regarding certain aspects of manufacture. An examination of these enquiries reveals that the problem which seems at present to be causing, perhaps, more trouble than any other is that of firing. In the majority of cases advice has been sought on account of complaints from London of "soft" teas, accompanied by instructions for higher firing. Where such instructions have been carried out only too often it has been found that the result expected has not been attained and no improvement has been effected in the teas produced. A considerable amount of attention has, therefore, been paid by the Institute Staff to drying conditions in various factories, with the result that certain faults have been found to be widely prevalent. In the first place it is quite common to find that the temperature recorded by the dryer thermometer is by no means accurate, this applying not only to thermometers of the ordinary type, but also to recording instruments. It is most desirable that these instruments should be periodically checked and a correction applied for any error found. A much more serious matter, however, is that far too little attention is paid to the temperature of the air leaving the dryer, or, in other words, to the temperature to which the leaf is subjected in the first tray. Two considerations have to be borne in mind. If this initial temperature is too low, then "stewing" occurs. Fermentation is not arrested sufficiently quickly and the teas are quickly spoilt. On the other hand, if the initial temperature is too high then "case hardening" is brought about. The surface of the tea is rapidly dried and hardened, leaving moisture in the inside which is not removed as the tea passes through the dryer. Such tea probably appears quite satisfactorily dried when it leaves the dryer, but on storage or during transit to London the internal moisture slowly diffuses through the leaf and the teas then appear soft and flat. In by far the larger number of cases recently investigated where soft teas have been complained of, it has been found that case hardening has been the cause, in other words the tea has been initially exposed to too *high* a temperature and not, as is usually supposed, underfired. As a general average figure it is probable that an exhaust temperature of about 115-120° will be found to give the most satisfactory results. At the same time an

inlet temperature of about 190° is generally suitable. The exhaust temperature can be readily controlled within reasonable limits by the thickness of spreading or by alterations in the fan speed of the dryer. Not only is a higher exhaust temperature detrimental to the tea but it is obvious that where it occurs the dryer is not working at its highest efficiency, and heat is being wasted.

Altogether the whole question of drying seems to require a good deal more attention than it usually receives. In this connection it may be of interest to refer to a possible development in the near future, that of electrical drying. A full account of the experiments recently carried out in Ceylon and in South India by Messrs Asea Electric Ltd., will be found in Sessional Paper No. XIII of 1931, issued in August last. The advantages of electrical heating lie in the ease of securing relatively close temperature control, the rapidity with which the required dryer temperature can be attained and the freedom from fumes liable to cause taints. There is also a saving of labour. The crux of the whole question is naturally the cost of electrical heating as compared with other methods. In the report in question it is claimed that the average power consumption for drying is about 0·6 unit per pound of fully-dried tea. Whether electric drying is likely to be widely employed in Ceylon would therefore seem to depend chiefly on the rate at which electric power can be supplied. This rate will have to be a low one to compete successfully with efficiently designed oil or wood-burning furnaces. Amongst these, largely increased efficiency and reduced working costs have recently been claimed for the Farbridge patent "Multiflu" dryers which have lately been put on the market. A number of these dryers has now been installed and, it is understood, they have given very satisfactory results.

Passing from drying to rolling, it is now generally recognised that undue heating of the leaf during rolling is highly detrimental. The question is of special importance in the low-country where high atmospheric temperatures make it particularly difficult to maintain suitable rolling conditions. Special interest therefore attaches to the Marshall-Boustead cooled rollers which are now on the market. An account of these with some data as to their performance will be found elsewhere in this issue.

## COVER CROPS.

The attention of our readers is invited to a series of articles by Mr. T. H. Holland which have appeared in recent numbers of the *The Tropical Agriculturist*. In these articles information of much value will be found dealing with the relative advantages of different species of shade trees and cover crops.

## NETTLE GRUB.

In view of a resolution passed by the Uva Planters' Association, which has been endorsed by the Estate Products Committee and the General Committee of the Planters' Association of Ceylon, steps are being taken for Nettle Grub to be declared a pest under the terms of Ordinance No. 10 of 1924. The declaration will apply to the Uva Province only.

## FACTORY HANDBOOK.

In view of the large number of requests received for copies of Dr. Evans' "Handbook of Factory Information" which was issued for use at the Institute's Conference in February, a revised and enlarged edition of this is in preparation which will be issued in January next.

## EMPIRE MARKETING BOARD.

Information has been received that in consequence of the reduction in the sums allotted to the Empire Marketing Board as a result of the present economic conditions, the Board will not be able to make a grant to the Institute for biological work. The grant was asked for to finance an enquiry into insect pests of tea and other crops in Ceylon and their parasites.

ROLAND V. NORRIS.

# THE "NETTLE GRUB" PEST OF TEA IN CEYLON.

G. DOUGLAS AUSTIN.

## INTRODUCTION.

The intensive study of these pests began in March 1929, when Mr. Austin was deputed by the Department of Agriculture to study the bionomics, parasites and possible methods of control of Nettle Grub in Passara. Seven months later the investigation was closed down for want of suitable accommodation in the district.

In April 1930, at the request of the Uva Planters' Association, the Institute took over the work, and Mr. Austin was seconded by Government for service with the Institute for a period of one year, which was later extended to the end of September 1931.

This extended investigation was made possible by the kind co-operation of Messrs. George Steuart & Co., and Mr. G. Kent Deaker, who placed a small bungalow on Gonakelle Estate at the disposal of the Institute for the purpose.

The article gives a record of data gathered since April, 1930, with a brief summary of historical data from about 1872 up to the present time.

C. B. REDMAN KING.

PART I.

1. Historical.
2. General Characteristics and Bionomics.

PART II.

The Species of Nettle Grubs affecting Tea.

PART III.

Control, Natural and Artificial.

## PART I.

### 1. HISTORICAL

The earliest record of a Nettle Grub, as a pest of economic importance was made by Neitner [1] in 1872, when he referred to *Parasa lepida*, the blue-striped Nettle Grub, then known as *Limacodes graciosa*, as a pest of coffee.

By 1890 *Parasa lepida* had assumed the status of a pest of tea, and is the only Nettle Grub described by Green in his "Pests of the Tea Plant" published that year.

The next authentic record of a Nettle Grub causing damage to tea is the same author's [5] reference to *Natada nararia* Mo., the Fringed Nettle Grub, which was reported from Badulla in November 1897.

It is presumed that Nettle Grubs were not much in evidence between 1890 and 1897, because Trimen, Director of the Royal Botanic Gardens, Peradeniya, in his Administration Report for 1893, wrote: "with the exception of *Helopeltis* the tea plant is remarkably free from serious pests."

1899, however, saw the first real outbreak of Nettle Grubs on tea when *Thosea recta** caused a considerable amount of alarm by appearing in large numbers in Morawak Korale during the months of June and July. Ever since then, this particular species of Nettle Grub has been known as the "Morawak Korale Nettle Grub".

In 1900, in response to a request from the Chairman of the Planters' Association, Green [5] published a circular on caterpillar pests of tea, in which he included very useful notes on the four species of Nettle Grubs known up till then, viz., *Parasa lepida*, *Natada nararia*, *Thosea recta* and *Thosea cana*. Commenting on *Natada* he wrote: "The Uva tea districts seem to enjoy almost a monoply of this species as a tea pest. Though it is a widely distributed insect throughout the Island, and certainly occurs in all the tea districts, yet I have received no reports of damage to tea, or of its occurrence in unusual numbers in the Central Province".

The same year (1910) *Natada* was reported for the first time from Passara, (in July) where "over 100 acres of tea on one estate were completely defoliated, and hundreds of coolies were employed in collecting and destroying the insects"; *Thosea cana* appeared at Elpitiya, and *Spatulicraspeda castaneiceps*—then known as *Spatulifimbria*—was recorded as a pest of tea, for the first time, when it was reported from the Kelani Valley.

In 1901, the only species of Nettle Grub recorded was *Natada* in August, and again from the Badulla district.

In 1903, *Scopelodes venora* [8] the largest Nettle Grub on tea, and one which fortunately is rather rare, was recorded from Peradeniya in June, while a small outbreak of Spatulicraspeda [8] was reported from Neboda in February.

In 1905 *Natada* appeared in Dolosbage during the months of March and April, while *Narosa conspersa* [9] the "green gelatine grub" assumed the importance of a pest of tea for the first time, having made its appearance in Uda-Pussellawa in the month of December.

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* It was the late F. M. Mackwood who identified this Nettle Grub during the outbreak in 1899: E. E. Green, the Government Entomologist, was away on furlough at the time.

In 1906, *Thosea recta* was recorded from Yatiyantota and *Natada* from Elkaduwa, while *Thosea cervina* was reported from Bandarawela by R. G. Coombe, who wrote that the grubs were "in millions" and attacking his "best flushing tea".

In 1907, *Thosea recta* was reported from near Kandy and the following year from Uva.

Green's remarks made 23 years ago are quoted in full below because the comments offered then are equally applicable to the present situation in Uva which is according to some "twenty times worse".

"This pest has done considerable harm in the Uva District where it appears to have occurred (periodically) for many years. It often necessitates a premature and costly pruning of the affected fields. I think that if all these estates attacked by this pest would co-operate towards its extermination, the work would eventually be cheaper and more satisfactory. Individual and isolated efforts only result in driving the pest to neighbouring estates. The ground between the bushes should be swept and all the fallen leaves burnt in order to destroy the pupae which are like small tea seeds in shape and colour".[12]

In 1910 *Natada* was reported from Rattota in June, and the following year from Wattegama in March and April.

In 1912, Green wrote in his Administration Report that he had "received no notice of Nettle Grubs" during the year.

By 1913 *Natada* was again serious in Badulla and Demodera, where "80 acres were said to be affected, and all the leaves dropping off the bushes"; *Thosea recta* and *Parasa lepida* were reported as causing damage to tea in Ratnapura, where the former had consumed ten acres of the crop.

In 1914 Elkaduwa reported *Natada* in August, while *Thosea recta* and *Thosea cana* did damage to tea in Ratnapura in January and March. In July, Rutherford [13] published his notes on Nettle Grubs referring to the five common species known up till then.

In October 1915 outbreaks of *Natada* were recorded from Madulsima, Namunukula and Pelmadulla, and from Dehiowita the following May.

From 1918 to 1920 *Natada* was the only species reported and outbreaks were recorded from Madulkelle in January, and Badulla in May (1918); Watawala in February (1919); Madulsima and Badulla in August, Passara in September and Peradeniya in October (1920). Hutson [15] commented as follows: "outbreaks of Nettle Grubs have occurred in unusual numbers in a few localities".

In 1921 *Natada* was reported from Badulla in March and September, from Passara in May, June and October, and Madulkelle in December, while both *Natada* and *Thosea cervina* were responsible for a serve outbreak in Wattegama.

In 1922 *Natada* was again reported from Dolosbage in February and October, from Passara in September, and Badulla in October; while *Thosea cervina* was recorded for the second time in Uva when it appeared near Badulla.

By 1923 the pest was obviously becoming wide-spread, and in Passara the damage to tea was so extensive that the local Planters' Association made a request to Government for an investigation on Nettle Grubs, and A. M. Clarke of El Teb offered to place an acre of tea at the disposal of the Department of Agriculture.

In June, the Government Entomologist (Dr. Hutson) carried out experiments with lead chromate, as a spray, on El Teb.

Early in the year Dr. Hutson [17] published a very descriptive article on the Fringed Nettle Grub (*Natada nararia*).

In 1924 *Thosea recta* was again reported from Morawak Korale, when it appeared at Deniyaya in October. *Natada* broke out in Passara in June, Maturata in July, and the following year at Dolosbage in June, and Elpitiya in October.

In 1926 *Natada* was once again reported from Passara in May, while both *Natada* and *Spatulicraspeda* were recorded to have appeared simultaneously at Elpitiya also in May.

1926 saw the opening of the Tea Research Institute of Ceylon when the investigations on Nettle Grubs and other pests of tea, (excluding Termites and Green Bug) were handed over by the Department of Agriculture to the Entomologist of the Institute.

Light [18] in his first report for the year recorded an outbreak of *Thosea cana* in the low-country, which "was entirely wiped out by an Ichnemon parasite".

Towards the middle of the year Dr. W. H. Brittain, Provincial Entomologist, Nova Scotia, accompanied by Dr. Hutson of Peradeniya, carried out experiments with calcium cyanide in Passara against *Natada*.

In 1927 *Natada* appeared in Passara in July and December, while a "gelatine grub", presumably *Narosa conspersa*, was recorded from Kandapola in December.

In 1928 the following resolution, passed at a General Meeting of the Uva Planters' Association, speaks for itself: "This Association views with alarm the spread of Nettle Grub in Uva and asks the Department of Agriculture to investigate this pest thoroughly."

This appeal was supplemented a few months later when the Department was again requested "to investigate (a) Green Bug (b) Shot-Hole Borer (c) Nettle Grub". The situation was that the Entomologist of the Tea Research Institute was then too occupied with the Tortrix problem to devote time to Nettle Grub and other pests of tea.

Consequently, Dr. Hutson, the Government Entomologist, made a survey of the situation in Uva and in submitting his report made the following observation: "I would suggest that Nettle Grub is rapidly assuming the dominating position in Uva that Tortrix holds in Maskeliya or parts of Dimbula, and until some such concerted action is taken against Nettle Grub as has been started by Tortrix estates, I do not see any prospect of any marked improvement in the situation".

This statement created a stir in planting circles and on further representations being made by the Uva Planters' Association Government decided "to station a junior officer of the Department in the Nettle Grub area in Uva early in 1929 for a further investigation of the measures which may be adopted for the control of these pests".

In 1929 (March) the writer was transferred to Passara fom Peradeniya to investigate the pest on behalf of the Department of Agriculture. During this period a study was made of the various species of Nettle Grubs and their parasites, and a spraying experiment was carried out on Gonakelle. In September the investigation was closed down temporarily for want of accommodation in the district. (A report on the work accomplished during the six months was read by F. P. Jepson—Acting Entomologist—at a meeting of the Estate Products Committee in Peradeniya on September 10th).

By the end of 1930 the situation in Uva was no better, and it was then realised that the problem was more serious than was originally realised.

The Tea Research Institute then agreed to widen the scope of the investigation by increasing the staff and affording further facilities. This was accomplished in May 1931 with a certain amount of financial assistance from the Ceylon Estates' Proprietary Association, when two field assistants were engaged and a temporary laboratory and insectary fitted up in the Passara District.

Subsequently, in October 1931, the writer was transferred to the permanent staff of the Tea Research Institute and work on Nettle Grub further intensified.

## 2. GENERAL REMARKS ON CHARACTERISTICS AND BIONOMICS.

"Nettle Grubs", also known as "Slug caterpillars", belong to the family *Limacodidae*, the characteristics of which are chiefly noticeable in the general appearance of the grubs, and their gliding or slug-like habit of movement.

*Moths* are a dull-brown or yellowish colour, with the exception of Parasa which is apple-green. They are small to medium in size and nocturnal in their habits.

*Eggs* are flat, oval, scab-like objects, almost transparent and with a shinny surface. They are deposited singly or in masses on both the upper and lower surfaces of mature leaves.

*Larvae* or grubs, are rather short, stout and oval in shape. A good many of the species are covered or armed with branching spines, while a few like *Narosa Belippa* and *Spatulicraspeda* are naked. Their heads are retractile and feet, though present, are hardly noticeable. Colouration is variable, apple-green being prominent and common to most species.

*Grubs* tend to be gregarious on reaching pupation and cocoons are frequently found clustered together.

*Cocoons* are hemispherical or oval in shape. Those made by the spineless grubs are whitish or greyish in colour and are conspicuously placed on the foliage towards the upper part of the tea bush, while the cocoons of those with spines are dark-brown in colour, and invariably found beneath the bush, round the collar, in the forks of branches, under dead leaves and stones, and at times in the soil. Nettle Grubs are somewhat widely distributed, having been reported to occur in practically every tea district in the Island. A perusal, however, of the list of localities would indicate that the pest appears more frequently in those planting districts which receive the benefits of only one monsoon.

## PART II.

### NUMBER OF SPECIES AFFECTING TEA.

Nine species of Nettle Grubs are known to feed on tea. With the exception of one i.e., *Belippa laleana*, the remaining eight were all discovered by Green, and it is quite likely that he was responsible for the common names associated with them.

### COMMON NAMES.

1. *Natada nararia* Mo. has been known as the "Fringed Nettle Grub" since 1900 when Green published his first notes on the Nettle Grubs known to attack tea. But in 1905, when referring to the same species, he mentioned the name "Small Nettle Grub". But

the former name has remained and is the most well known today. Since November, 1897, when *Natada nararia* was first reported from the Badulla district as damaging tea, it has remained the commonest Nettle Grub on this crop with the widest distribution, having been recorded from as many as twenty planting districts.

2. *Thosea cervina* Mo. was a recognized pest of tea in India before it was found in Ceylon and consequently its common names emanated from that country where it is still known as either the "Assam Nettle Grub" or the "Assam Tea Seed Moth". But on *T. cervina* assuming a status of economic importance in Ceylon in 1906, Green suggested that "to distinguish it from its allies the species might be called the 'saddle-backed Nettle Grub' , but this name does not appear to have been remembered again. Up to the present it remains the one Nettle Grub without a local common name.

3. *Thosea recta* Hmp. On account of the serious damage it caused to tea in the Morawak Korale District in the Southern Province, it has since 1899 been called the "Morawak Korale Nettle Grub."

4. *Thosea cana* Wlk. has been known as the "Green Nettle Grub" since 1900.

5. *Spatulicraspeda castaneiceps* Hmp. is occasionally referred to as the "Red-banded Nettle Grub".

6. *Parasa lepida* Cram. has all along been called the "Blue-striped Nettle Grub" owing to the characteristic blue bands on its back.

7. *Scopelodes venosa* Wk. owing to its size is still known as the "Large Nettle Grub".

8. *Narosa conspersa* Wlk. has of late been called a "Gelatine Grub". It might, however, be necessary to call it the "Green Gelatine Grub" in order to distinguish it from *Belippa laleana*, another gelatine grub, also found on tea.

9. *Belippa laleana* Mo. was the first to be called a "Gelatine Grub" when it was recorded by Speyer fourteen years ago. Recently it has been found in Madulsima, but not in such large numbers as Narosa. Compared with Narosa, *Belippa laleana* is of a bluish-green colour and its original common name "Gelatine Grub" should be allowed to remain.

Nettle Grubs have their equivalent in the vernaculars. The Sinhalese and Tamils call them "*Gini Panuwo*" and "*Eri Poochie*" respectively, "Gini" and "Eri" both mean fire or something which burns, while "panuwo" signifies caterpillars or grubs, and "poochie" is a common term applied to insects in general.

## DISTRIBUTION.

The following is a list of localities from which the nine species of tea Nettle Grubs have been reported to occur:

*Natada nararia* Mo.

Aranayake
Badulla
Bandarawela
Dehiowita
Demodera
Dolosbage
Elkaduwa
Elpitiya
Galle
Haldummulla
Haputale
Kalutara District
Lunugala
Madulkelle
Madulsima
Matale
Maturata
Namunukula
Nawalapitiya
Passara
Pelmadulla
Peradeniya
Pussellawa
Rangalla
Rattota
Talawakelle
Watawala
Wattegama.

*Spatulicraspeda castaneiceps* Ham.

Badulla
Elpitiya
Kelani Valley
Lunugala
Neboda
Passara

*Thosea cervina* Mo.

Badulla
Bandarawela
Demodera
Dolosbage
Galaha
Haldummulla
Haputale
Lunugala
Madulkelle
Madulsima
Namunukula
Passara
Pussellawa
Wattegama

*Thosea cana* Wlk.

Avisawella
Balangoda
Elpitiya
Ratnapura

*Scopelodes venosa* Wlk.

Demodera
Passara
Peradeniya

*Belippa laleana* Mo.

Badulla
Madulsima.

*Thosea recta*

Badulla
Bandarawela
Demodera
Deniyaya
Haputale
Kandy
Lunugala
Madulsima
Morawak Korale
Passara
Pussellawa
Ratnapura
Talawakelle
Yatiyantota

*Narosa conspersa* Wlk.

Badulla
Bandarawela
Haputale
Kandapola
Lunugala
Madulsima
Maskeliya
Passara
Talawakelle
Uda-Pussellawa

*Parasa lepida* Cram.

Badulla
Madulsima.
Passara
Pussellawa
Ratnapura

## SEASONAL HISTORY.

No definite conclusions can at present be drawn as to the seasonal history of the different species of Nettle Grubs. More accurate observations are necessary before it can be definitely stated that Nettle Grubs are a dry weather pest. This is, of course, a popular opinion held by several in Uva. In Passara the writer has seen equally severe outbreaks occur during both the rainiest and driest seasons of the year.

A chart prepared from a census of reported outbreaks between 1897 and 1930 indicates that Nettle Grubs were worst during the months of May, August and October.

## MIGRATION AND DISPERSION.

No migration has actually been observed. But that migrations periodically take place at night is suggested by the various outbreaks which occur in different parts of an estate, and sometimes a considerable distance from any other infested area.

Several are inclined to believe that strong winds are responsible for the dispersal of moths. This is not the case. Moths and a good proportion of insects in general are apt to be very still or inactive on windy nights.

The writer, however, has on one occasion observed that strong blowing was responsible for the dispersal of *grubs*.

During an outbreak of *Natada* in Passara, in the month of June, grubs were as plentiful on dadaps as they were on tea. The superintendent of the estate attacked decided that the tea should be sprayed and the dadaps lopped and foliage burnt. That night the S.W. Monsoon blew over the downs of Uva, and by morning not a single Nettle Grub could be found on those dadaps which were to be lopped. Grubs were found in a field several hundred yards away which till the previous day had remained free of the pest.

Moths, in general, are mainly responsible for the dispersion of the pest.

What might be termed "artificial dispersion" was once observed by the writer while travelling at night by bus from Badulla to Passara. On the climb approaching Debedde, the bus was obliged to stop for a short while. Within a couple of minutes one female and two male *Natada* moths were attracted to the light inside the bus and remained resting on the hood till Passara was reached. The driver volunteered the information that on some nights these moths arrived in hundreds and were a nuisance.

Here is a possible explanation, and perhaps a contributory cause, of the wide distribution of Nettle Glubs in Uva and other districts during recent years.

The transport of tea seedlings from one district to another is perhaps another method of dispersion that requires further investigation. Nettle Grubs have been found to breed in tea nurseries and it is quite conceivable, if Nettle Grubs were originally limited to Uva, that their distribution to other tea districts was brought about by the transport of infested material.

The proposed legislation (if Nettle Grub is declared a pest) should prevent its further spread by declaring areas "infested" and prohibiting the "removal or reception" of plants from such areas.

Legislation should check the spread, at least of *Thosea cervina*, into the low-country, where this formidable Nettle Grub may adopt a taste for coconuts.

It was found on coconuts in the Andaman Islands in 1924 and recorded in the Peradeniya files.

## LARVAL MIGRATION.

This is a characteristic feature which is not uncommon among certain kinds of caterpillars. These migrations invariably occur when the grubs or caterpillars are a little more than half grown. The stimulus, or motive, which prompts such a migration is, as in the case of moths and butterflies, either a lack of food, or some disturbance caused by weather conditions.

Larval migrations may occur from one part of the host plant to another, from the host to another plant in the same locality, or from its original habitat to that of another.

The writer has personally not seen a migration take place among Nettle Grubs, but would wish to comment on an observation recorded by Hutson [19] who wrote "during periods of heavy rains the Nettle Grubs mostly left the tea and assembled in thousands on the under side of the interplanted dadaps, presumably for the better protection afforded by the larger leaves. By keeping the dadaps denuded of their leaves during the wetter months, the Nettle Grubs were deprived of adequate shelter and returned to the tea whence they could be more easily collected."

It would be interesting to know whether similar observations have been made by others. Where shelter is concerned, the writer would submit that a tea bush offers more protection to a Nettle Grub than a large-leaved dadap, especially during the rains in Uva.

However, if such migrations are a feature of Nettle Grubs, the question of control appears to be a very simple matter.

It would be easier and more practicable to lop the dadap carrying Nettle Grubs than to prune infested tea. Pieces of jute hessian stitched together and stretched beneath the dadaps would prevent Nettle Grubs dropping down to the tea. If the dadaps were wanted and lopping considered undesirable at the time, the alternative would be to apply a tanglefoot round the trunks of the dadaps to prevent the grubs crawling down, and to spray or dust the foliage with some contact insecticide. A spray or a dust would be more effective on a Nettle Grub while it was on a dadap than if it were hidden within a tea bush.

## FOOD PLANTS.

While tea is undoubtedly its favourite host plant, grubs have been recorded to feed on:—

Dadaps (*Erythrina lithosperma*)
*Gliricidia maculata*
*Crotalaria* spp.
*Tephrosia candida*
Blue Gum (*Eucalyptus globulus*)
Toona (*Cedrela toona*)
*Ficus religiosa*
*Citrus* spp
Roses
Honeysuckle and
Cannas in Passara

Hutson [24] has recorded the following as compiled from Peradeniya records:—

*Bignonias* spp.
*Eucalyptus robusta*
*Psidium polycarpon*
*Castanospermum australe*
*Tecoma stans*
*Thunbergia laurifolia* and
*Rubus ellipticus.*

## NATURAL ENEMIES.

Nettle Grubs have quite a variety of natural enemies, which, at certain seasons of the year, contribute to the control of the pest considerably. These natural enemies, on the whole, attack the pest while it is in the larval or grub stage. No egg parasites have hitherto been found.

The following are some of the more potential parasites, which have been observed up to date:—

## PARASITES.

*Fornicia ceylonica* Wilkn. is a small hymenopterous wasp belonging to the family Braconidae. It appears to be more a parasite of *Natada nararia* than any other Nettle Grub. It has, however, been bred from *Thosea cervina* and *Thosea recta*. Parasitised grubs turn a bright-yellow and are very conspicuous on the tea.

*Rhogas* sp., also a Braconid and like Fornicia, is a solitary larval parasite. It is of a brownish colour, and females possess a distinct ovipositor. It parasitises nearly all the species of Nettle Grubs and has been reared from *Thosea cervina*, *Thosea recta*, *Natada nararia*, *Narosa conspersa*, and *Parasa lepida*.

*Apanteles* sp. is a gregarious larval parasite, also a Braconid, and is known to attack *Thosea cervina*, *Thosea recta* and *Parasa lepida*. Adult parasites emerge from grubs almost full grown. Tachinids or fly parasites, yet unidentified, have occasionally emerged from the cocoons of *Thosea cervina*, *T. recta*, *Parasa lepida* and *Natada nararia*.

## PREDATORS.

*Canthecona robusta* Dist, is a predaceous Pentatomid bug which is particularly fond of *Natada nararia*, but in the laboratory has been observed to feed on all species of Nettle Grubs offered. Both adults and nymphs are predatory in their habits.

*Oecophylla smaragdina* Fb. the large 'red ant' is said to be a formidable enemy of Nettle Grubs. But it has yet to be demonstrated that these insectivorous ants attack either the grubs of the emerging moths.

## BIRDS.

The only bird known to feed on Nettle Grubs is the crow (*Corvus splendens*). Green records that on a visit to the Kelani Valley in 1900 he was informed that "during a bad attack of the pest (Nettle Grubs) the crows were said to have gorged themselves with the caterpillars until they could scarcely rise from the ground".

## DISEASES.

"Wilt" disease is undoubtedly the most effective controlling factor, and is very often largely responsible for the so-called 'disappearance' of Nettle Grubs from infested areas.

*Natada nararia* appears to be the species of Nettle Grubs most susceptible to this disease. A point which requires further investigation is whether Wilt has been responsible for the partial elimination of *Natada* from those localities where, till recent years, it has

remained the dominant species of Nettle Grubs. Or, in the converse, whether *Thosea cervina*, owing to its apparent powers of resistance against Wilt, has succeeded in predominating over *Natada* in a few areas. Wilt attacks both the young as well as the older larval stages of Nettle Grubs, and "food shortage" and "overcrowding" are by no means the only causes conducive to an epidemic. Severe attacks of Wilt have been observed where grubs were few and far between and the food supply almost unlimited.

## CATERPILLARS MISTAKEN FOR, OR ASSOCIATED WITH, NETTLE GRUBS

*Heterusia cingala* Mo. the 'Red Slug' is very frequently mistaken for a Nettle Grub. This caterpillar is reddish-brown in colour and though called a "slug" is not so sluggish in its movements as most Nettle Grubs. It is active when disturbed. Damage consists in the caterpillars defoliating mostly the very mature leaves at the bottom of the bush. Cocoons are formed within the folds of leaves. The moths are beautifully marked and are attracted to lights.

The following is a list of hairy caterpillars, found on tea and dadaps, and occasionally reported as "Nettle Grubs":—

*Dasychira horsfieldi* Saund. The Yellow Tussock.

*Notolophus* (*Orgyia*) *posticus* Wlk. The Small Tussock Moth.

*Attacus atlas* L. The Atlas Moth.

*Taragama dorsalis* Wlk. The Dadap Hairy Caterpillar.

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(To be continued.)

# COOLED ROLLERS.

ROLAND V. NORRIS.

It has been well said in a recent publication on the manufacture of tea that unnecessary heat is the enemy of quality. In no stage of manufacture is there more risk of excessive development of heat than during rolling. Such heat development, as has already been pointed out in these pages, while partly caused by the mechanical friction of the roll is much more due to the chemical action taking place in the leaf when the leaf juices are expressed. The extent of such heat production is not, perhaps, generally recognised but, means uncommon to find the leaf in the rollers at a temperature unless suitable precautions are taken during rolling, it is by no more than 20° in excess of that of the rolling room. There can be no question that such temperatures are highly detrimental to fermentation and result in a definite loss of quality in the tea.

Up to the present the only means available for controlling such rises of temperature have consisted in various devices for maintaining the rolling room as cool as possible and in careful regulation of the pressure used during rolling, the pressure cap being raised at frequent intervals to allow the leaf to cool off before pressure is again applied. Such methods have their limitations, however, with the result that, in the low-country in particular, in many factories the number of rolls that can be carried out and the degree of pressure that can be employed are both restricted to a point below what would otherwise be considered advantageous.

A totally different method of overcoming the above difficulties has recently been patented and put on the market in the form of the Marshall-Boustead cooled rollers. By the courtesy of Messrs. Boustead Bros. and the Superintendent, New Peacock Estate, an opportunity was recently afforded the writer to inspect a battery of such rollers and to collect some data as to their performance.

The essential principle of the new rollers lies in the provision of means by which a stream of chilled calcium brine can be circulated through the rollers, whereby the temperature of the leaf, even in a long series of rolls, can be maintained at the temperature of the room or lower.

The rollers themselves are the ordinary double action Marshall rapid rollers but the table, leaf box and pressure cap are each jacketed, the jackets being connected by means of flexible piping to the main brine pipe line running along the side of the rolling room behind the rollers. By means of a centrifugal pump the brine, which has been cooled to the desired temperature in an ammonia

type refrigerating plant, designed by the Lightfoot Refrigeration Co., is circulated through the jacketed parts of the rollers, the volume thus circulating to each roller being readily and easily controlled by means of screw cocks on the distributing pipes. The temperature to which the brine is originally cooled is easily regulated and, by manipulation of the valves referred to above, any desired degree of cooling in the roller can be maintained without difficulty. The control of the plant is, in fact, very simple and effective and should present no difficulty in ordinary factory working. In practice the rate of flow is regulated according to the temperature of the exhaust brine as indicated by thermometers fixed in the return pipe lines, normaly about 1,500 gallons of brine per hour being circulated through four rollers.

On the day the inspection was made, manufacture was carried out simultaneously, both in the cooled rollers and in ordinary rollers so that it was possible to obtain comparative data, both in regard to rolling and to the teas ultimately produced.

*Temperature production.*—The table below shows the temperatures of the rolled leaf of each dhool in the two sets of rollers:—

TABLE I.

| No. of dhool | Temperature of leaf leaving the rollers | | Room Temperature |
|---|---|---|---|
| | A. Cooled Rollers. °F. | B. Ordinary Rollers °F. | °F. |
| 1 ... | 67 ... | 81 ... | 70 |
| 2 ... | 66 ... | 80 ... | 70 |
| 3 ... | 65 ... | 80 ... | 71 |
| 4 ... | 65 ... | 85 ... | 72 |
| 5 ... | 66 ... | 88 ... | 72 |
| 6 ... | 64 ... | — ... | 73 |

The leaf was rolled six times in the refrigerated rollers as against five times in the ordinary rollers. It will be seen that the difference in temperature of the leaf in the two sets varied between 14°-22° in favour of the cooled rollers, the leaf from the latter being throughout at a lower temperature than that of the room, while in the ordinary rollers the leaf attained a temperature 16° in excess of room temperature in the 5th roll.

The brine entering the cooled rollers was at a temperature of 25° F. for the first roll and increased in temperature to about 30°. During the subsequent rolls the brine temperatures were approximately 30° and 35° in the inlet and outlet pipes. An idea of the quantity of heat developed during rolling can be obtained when it is realised that nearly 375 gallons of brine were heated about 5° in the course of one hour, when about 300 lbs. leaf were being rolled.

*Separation of dhools.*—The quantity of leaf separated in each dhool is shown in Table II below. In the case of the refrigerated rollers, no pressure was applied in the first three rolls, light pressure in the fourth and fairly heavy pressure in the last two rolls. In the case of the normal rollers, no pressure was applied in the first roll, light pressure in the second, half pressure in the third and full pressure in the fourth and fifth rolls. In both cases the speed of rolling was about 40 revolutions per minute.

TABLE II.

| No. of Roll | Percentage dhool obtained | |
|---|---|---|
| | Refrigerated Rollers | Ordinary Rollers |
| 1 ... | 9·9 ... | 9·1 |
| 2 ... | 11·9 ... | 9·1 |
| 3 ... | 14·9 ... | 9·1 |
| 4 ... | 20·0 ... | 20·9 |
| 5 ... | 16·2 ... | 30·8 |
| 6 ... | 20·1 ... | — |
| Big bulk ... | 7·0 ... | 21·0 |

The leaf coming out of the last roll with the cooled rollers had undergone but little fermentation and had still a bright-green colour, whereas in the case of the ordinary rollers even the third dhool was a copper-brown colour.

*Composition of dhools.*—Analysis of the dhool samples showed that the loss of tannin as between the second and the last dhools was about 0·7% in the cooled rollers as compared with a loss of about 1·2% during rolling in the ordinary plant. There was also a slight difference, in favour of the cooled rollers, in the water-soluble content of the two sets of teas. These two factors definitely point to an improvement in quality and body of the liquors as a result of employing the new rollers.

*Made teas.*—The above conclusions were borne out by the comparison of the two sets of made tea, the samples from the cooled rollers being generally preferable in quality and strength to those made the normal way. The fourth and fifth dhools from the normal rollers gave rather soft liquors without much briskness and were inferior to the teas from corresponding dhools from the refrigerated rollers.

Arising from the above considerations it may be said that the new type of roller appears to offer very definite advantages, particularly in the case of low and mid-country manufacture.

Under the temperature conditions prevailing at such elevations, the number of rolls that can be carried out is definitely limited by the amount of heating to which the leaf is subjected during rolling. With the new rollers, this objection does not apply and it is thus possible to reduce very considerably the percentage of big bulk without any risk of over-fermentation. It should thus be practicable to increase the percentage of the more remunerative grades without recourse to repeated cutting. The gain is thus twofold; first a general improvement in quality and secondly, a greater amount of the better grades.

Again, with the cooled rollers, less attention need be paid to the cooling of the rolling room generally, a matter which is frequently difficult to carry out at low elevations. Practically, no fermentation takes place in the chilled rollers and this process can be carried out in a separate, smaller room in which temperature and humidity can be much more easily controlled.

*Economic considerations.*—From the point of view of initial cost, the chief item is the refrigerating plant as the cost of the actual rollers should not largely exceed that of ordinary rollers. Only one refrigerating plant is of course required, the capacity of this depending on the number of rollers to be used. At the time the plant was inspected, the price had not been finally settled. We understand that definite quotations can now be obtained from Messrs. Walker, Sons & Co. Ltd., Colombo. It is anticipated that quotations will also shortly be available for the conversion of existing rollers.

As regards running costs, certain additional power is required for the refrigerator and the slightly heavier rollers. This, we are informed, amounts to 14-15 H.P. in the case of the four-unit set inspected. Apart from such additional power, there seems little reason why running costs should be any higher than with ordinary rollers. The whole plant is simple in construction and maintenance charges should be low.

In view of the very definite advantages in manufacture which these rollers would appear to afford, it is greatly to be hoped that they may receive an extensive trial.

# 18th REPORT OF THE IMPERIAL ECONOMIC COMMITTEE—TEA.

## (REVIEW)

The present note deals only with Section XIII of the Report which relates to Research in relation to Tea and its organisation.

The Imperial Economic Committee consisted of representatives of the United Kingdom and the various Dominions, Colonies and India. Sir Gilbert Grindle and Mr. J. M. Batty represented the Colonies and Protectorates with Mr. F. A. Stockdale as their Adviser. It is to be regretted that no details are given in the report as to the witnesses examined, so it is not possible to assess what technical advice was at the disposal of the Committee in framing their recommendations.

The section under reference details the research organisations in Ceylon and India, compares these with arrangements in the Dutch East Indies and makes a number of general recommendations as to organisation and also as to certain lines of work which it considers should receive attention.

*Paras 126* and *127*.—These describe the organisation of tea research in Ceylon, India, and the Dutch East Indies.

*Para 128*.—Arising from the above, the Committee stresses the importance attached in the Dutch East Indies to the provision of a large staff of "general agriculturists" as opposed to more specialised officers and evidently considers such an arrangement preferable to that found in Ceylon and India, where it considers that undue stress has been laid on pathological research and the provision of specialists to deal with pests and diseases. The views of the Committee are really summed up in the sentence that "Crop husbandry in its broadest sense should form the basis for the training of all agriculturists."

The comparison between the organisation for research in India, Ceylon and Java is somewhat beside the point. The research organisation in any country will depend upon the requirements of that country, consequently one with a large number of small-holders will require a vastly different organisation from another where the industry is mainly in the hands of educated and experienced agriculturists.

That in many parts of the British Empire specialists have been provided for dealing with pests and diseases is prefectly true and is best understood if the history of agricultural research in the tropics is considered. But it does not follow that crop production and

general husbandry have not received the attention they deserve. Agricultural research in Ceylon was the direct consequence of the coffee crash. The planters themselves were competent to look after the cultural needs of the new crops, such as tea and rubber; but, in order to avoid a similar disaster from pests and diseases, they demanded that specialists be provided for the specialised study of diseases and pests. That progress has been made on the purely agricultural side in the absence of professional research workers is apparent.

We also dissent from the statement that crop husbandry, in its broadest sense, should form the basis for the training of all agriculturists, if by agriculturist is meant—as it appears to mean from the context—agricultural research workers of all branches. Officers too generally trained do not prove the best research workers and are frequently not more suited for *research* than are estate superintendents who have frequently received a similar training. Research and demonstration are too much confounded throughout these paragraphs on research. The Committee emphasises that a staff of eleven "agriculturists" is employed in the Dutch East Indies. But most of these officers are not attached to the Tea Research Institute at Buitenzorg, but belong to a larger research organisation for hill land cultivations of Java and Sumatra. The Buitenzorg Tea Research Institute, it is understood, comprises a staff of nine scientific officers, most of whom are specialised officers as in the Ceylon and India Institutes. It is to be presumed that these other officers, who form part of a staff of thirty-eight, are engaged mainly in demonstration work as apart from research and this view is supported by other sections of the report. So far as the organisation of the various research Institutes is concerned, the comparison between Java and Ceylon or India seems, therefore, to be based on a misunderstanding.

We would stress that, so far as reseach is concerned, the best results are likely to be obtained by the carefully co-ordinated team work of specialised officers. Such a conclusion is fully supported by work in other lines, of which medicine is a notable example, and has indeed been one of the most marked features of the organisation of research in widely varied fields in recent years.

On the above basis the organisation of the Ceylon Institute would appear to be on the right lines. The difference of opinion is really not so much in regard to the problems demanding attention but as to the method in which these should be approached. Thus, considering physiology, the importance of the study of the tea bush itself and of a physiological investigation of its reactions under

different cultural conditions has been repeatedly stressed in all announcements detailing the Institute programme of work but we do not consider that such work can best be handled by "general agriculturists".

*Paras 129* and *130.*—These sections discuss the measures necessary for co-ordinating research and for bringing the results to the notice of the practical man in the field.

Dealing with the latter point first, the Committee hardly seems to be aware as to what is being done in this direction in Ceylon. Every facility is given to planters to visit St. Coombs and to discuss their particular problems and the work in progress at the Institute. The Institute Conferences provide another opportunity, which has been well utilised, for full discussion on the major problems of the Industry. The attention of District Planters' Associations has been called to the fact that members of the Institute. Staff will be deputed to address their meetings when so desired and many lectures summarising the Institute's views have, in fact, been given. Again, contact between the Scientific Staff and the practical planter has been systematically promoted by the encouragement and facilities given to members of the Staff to visit estates. Subject to undue interference with laboratory work, no request for such a visit is ever refused and this is, we think, now more fully realised by the various districts, as is evidenced by the very striking increase in the applications received for such visits. Finally, by means of the Institute's publications, which are supplied gratis to all Estate Agencies and Superintendents of estates, full publicity is given to the work in hand and the recommendations of the Staff. There therefore, seems little excuse for any planter in Ceylon to be ignorant, either as to the work of the Institute or as to the facilities available for his assistance.

Considering next the question of co-operation between the Ceylon and Indian Research Stations, the report makes the statement that there is no adequate co-operation between Ceylon and India. One would very much like to know on what evidence this is based. It is doubtful whether the Committee was aware of the exchange of views which takes place by correspondence between the Staffs of the three Institutes, more particularly in regard to field experiments and manufacture. On the occasion of the Institute's Conference, invitations to attend were sent to the staff not only of the Indian stations but also to workers in Java and the Directors of both Indian stations were present, when the fullest use was made of the opportunity to discuss the various lines of work in progess.

In regard to the specific recommendation made, we welcome the proposal for occasional exchange of visits between workers in Ceylon and India which can lead to nothing but good. In regard to the second proposal, a formal exchange of programmes can serve no useful purpose. The need for such is eliminated by the exchange of visits and other means of co-operation. A programme of work may be given in such general terms as to be almost valueless. On the other hand if the exact method of attacking a particular problem is detailed, it is unlikely that an institution in one country will withhold work on that problem if the problem is of immediate importance there, merely because the problem occurs in another institution's programme of work.

The third recommendation is that an exchange of workers for tours of duty should be occasionally made. This we consider quite impracticable.

The fourth recommendation is for periodical conferences between the workers of each country which should be attended by representaives of the planting community. So far as Ceylon is concerned, this is already met by the Institute's Conferences and we have no doubt, should facilities be given for officers of the Ceylon Institute to visit India, the opportunity would be taken during such visits for similar conferences in India.

It is to be regretted that the Committee did not seem to be fully informed as to the steps already taken to promote co-operation between Ceylon and India and such criticisms as have been made hardly seem justified in the actual facts.

*Paras 131-135.*—In these paragraphs is stressed the importance of close co-operation between the marketing and financial interests in London and the research worker. We agree that it is desirable that London should be kept fully informed as to the lines of research in progress and the results achieved, because without the support of London such results may not be fully taken advantage of on estates. This has always been recognised by the Institute. London interests receive the Institute's publications and the Ceylon Association in London has always provided a ready means of communication between the Institute and other interests. Advantage can also be taken of the presence of officers on home leave to establish personal contact with such interests. Something in this direction has already been done.

The Committee concludes this section by recommending the establishment in London of a Joint Advisory Committee, representative of the financial tea interests in the United Kingdom and of the Indian and Ceylon tea interests, "to act as an Advisory Committee to the Tea Research Stations in India and Ceylon as well as a clearing house in regard to all scientific matters concerning tea".

It is possible such a Committee might do something in the latter direction, more particularly in keeping the research worker more closely in touch with trade requirements and market conditions. In other matters direct contact between the various research stations can really provide the information required much more rapidly and at much less cost, while there already exist the various Imperial Bureaux which act as clearing houses on technical questions.

The suggestion, however, that such a Committee should act in an "advisory" capacity is one which we consider should be definitely resisted. Many of the members would probably be unfamiliar with local conditions, or at any rate out of immediate touch with such conditions, and it is not easy to see how they could be really helpful On the other hand, it is by no means improbable that suggestions would be put forward which, backed by the prestige such a Committee might be assumed to acquire, might prove distinctly embarrassing to the Institute and limit its freedom of action.

*Para 136.*—This deals with the question of research on plant material and the assumption is at once made that it is at Tocklai that work in the improvement of plant material should be concentrated. It is difficult to understand this view. Conditions in N. India and Ceylon are so entirely different that, in our opinion, such work must be duplicated in Ceylon, the two stations naturally being mutually informed of all results achieved.

We fully appreciate the necessity for such investigations but entirely disagree with the suggestion that the best prospects can be expected from genetical work. On the contrary, we do not believe any rapid advance will be achieved from such a line of attack. The question need not be enlarged on here as it is fully covered in a separate memorandum dealing with the proposed establishment of Government tea seed gardens. It is sufficient to say here that we consider better results are likely to be obtained by a thorough study of the clonal propagation of selected material. As a preliminary to this, some experiments on the vegetative propagation of tea has already been made.

The Committee frequently emphasizes the necessity of preventing the overlapping of work at the Indian and Ceylon stations. It is true they recognise that in some cases climatic conditions will necessitate similar work being carried out at both stations. We think they have hardly realised that the above qualifications would apply to nearly all the major problems under investigation. There seems to be an unnecessary fear of two officers in different parts of the world attacking the same problem. The probabilities are that they will attack from different angles and probably get different (though

not opposite) results. This so-called "overlapping of work" is on a par with the duplication of experimental plots and, with reasonable co-ordination, is just as useful.

*Para 137.*—Engineering Research. The Committee recommends the appointment to the Institute Staff of a technical officer trained in chemical engineering. Such an appointment, with the necessary provision for the equipment and working expenses of an engineering section, would be extremely costly and it is doubtful whether conditions in Ceylon justify the expense.

There are in the Island a number of competent engineering firms actively engaged in carrying out investigations on tea machinery. The Board has already laid down conditions, by no means onerous, by which plant in the experimental or later stages can be tested out in the Institute's factory. Moreover, under the present programme of work, considerable attention is paid to the accumulation of data in regard to withering, rolling, humidification, and other engineering problems and much information of value has already been obtained. Such data is freely at the disposal of any of the engineering firms. Similar assistance is given to estates, the staff being frequently employed in observations in estate factories of the performance of different system of withering, rolling, firing, etc.

*Para 138.*—It is doubtful whether the small-holder experiences undue difficulty in getting his tea made and we imagine in most cases co-operative factors would not be feasible.

*Paras 139-140.*—Tea Seed Gardens.—This question is reviewed in a separate article.

*Para 141.*—Inspection staff for control of pests and diseases. The organisation for such work, as pointed out in the report, already exists but might perhaps be improved in efficiency.

*Para 142.*—Tea Tortrix. The Committee was evidently under the impression that the Institute's application to the Empire Marketing Board was for financial assistance in the control of Tortrix only. This was not the case, the grant being required for a general survey of insect pests of tea and other crops in Ceylon and of their parasites. Further representations have been made to the Empire Marketing Board on the matter.

In conclusion, the feeling cannot be avoided that the Committee was not too well informed of the present position in regard to tea research in Ceylon and that thereby the usefulness of some of their recommendations has been somewhat vitiated, while in other cases their suggestions have already been anticipated and brought into effect.

ROLAND V. NORRIS.

# ESTABLISHMENT OF TEA SEED GARDENS.

ROLAND V. NORRIS.

In Paragraph 139 of the 18th Report of the Imperial Economic Committee, the Committee recommends that immediate steps should be taken for the establishment in Ceylon, at high elevations, of tea seed gardens for the supply of tea seed of the highest proved quality and further suggests that this work should be the responsibility of the Government.

Both in the paragraph under reference and in a previous section, para 139, the Committee stresses "the importance of the selection and supply of a pure strain" and remarks that "considerable improvement in plant material might result from the labours of the plant breeder or geneticist".

It is not altogether clear whether the Committee's proposal is that the suggested seed gardens should be formed from such types of seed as are already available, or whether they envisage the early isolation of pure and improved strains from which seed supplies should ultimately be made available. If the latter, then there would appear to be considerable misunderstanding as to the nature of the problem.

The jâts of tea now grown are of highly mixed ancestry, and the mere breeding out of any pure strains from such stock would occupy a very considerable number of years. Even assuming, however, that pure strains could eventually be obtained, these would then have to be further tested out both in regard to their suitability for different tea areas and the "quality" of the tea derived from them. Such work would occupy a further very long interval, but it would be quite impracticable to establish seed gardens, or commence seed distribution, until such points had been satisfactorily cleared up. It may, therefore, be said that, on such lines, there would be little likelihood of the establishment of seed gardens in any reasonable period of time.

If, on the other hand, the Committee's intention is merely that such gardens should be laid down with seed from existing jâts there are again several criticisms which must be made in regard to the procedure suggested.

Little is yet known regarding the relationship between jât and "quality", to mention but one point only, and it would appear highly problematical whether expenditure on the establishment of Government seed gardens would be justified in the present stage of our knowledge. To provide for areas of different elevations and under very varying climatic conditions, a number of different

jâts would have to be utilised, and any such selection at the present time would necessarily have to be made on very limited data.

The Committee's recommendation is that the proposed seed gardens should be established at high elevations. They themselves recognise, however, that if, as seems probable, the present policy of Government be maintained, the greater area of any new openings in tea will be in the low and mid-country. It is true that existing estates at high elevations will require material for replacements, but loss from disease and other causes is much more severe in the low-country and, even on a replacement basis alone, it seems likely that the demands from the low-country for seed would exceed those from higher elevations. In these circumstances it is by no means certain that that seed gardens, if established, should be confined to high elevations. It is more likely that it would be found necessary to distribute such gardens at different elevations and in different climatic zones, to deal with the requirements of different areas.

In advocating the establishment of seed gardens, the Committee has obviously been influenced by the desirability of securing adequate supplies of good seed at reasonable prices. It is perfectly true that prices of tea seed have at times been unduly high, but this state of affairs has largely brought about its own remedy and prices have already dropped to much more reasonable figures.

The expense of establishing Government seed gardens in different areas will be heavy and it is problematical, to say the least, whether seed could be supplied from such gardens at appreciably lower rates than those which now obtain. So far as economic considerations are concerned there seems, therefore, little reason why the supply of seed should not be left to private enterprise.

The considerations above outlined are not in any way intended to minimise the desirability for investigations and research into the possible improvement of plant material, and such work forms part of the Institute's programme. It is suggested, however, that quicker results will be obtained by a different method of approach. The difficulties of breeding out pure lines of seed have already been referred to and it would appear more profitable to examine the possibilities of the *vegetative* propagation of tea. The initial difficulties of selection will, it is true, still have to be faced, but the subsequent multiplication of material of uniform type would probably be attained much more rapidly than by genetical work. Clonal propagation, which has already attracted considerable attention in Java should, therefore, be thoroughly tested and some preliminary experiments on vegetative propagation have, in fact, already been made by the Institute.

# EFFECT OF BURNING GRASS LAND ON THE WHITE GRUB (ANOMALA sp.) POPULATION.

C. B. REDMAN KING.

A small area of ground was opened up this year by the Soil Chemist for experimental work. It was divided into a number of plots about one twentieth of an acre in extent which were arranged in pairs, one of each pair being burned over first, the other being forked only. It seemed a good opportunity to find out whether the burning of the grass had any effect on the White Grubs present in the roots of the grass.

Six pairs of plots were chosen for sampling, and three random samples were taken from each of the twelve plots, each sample consisting of a count of the grubs in one square foot of soil. The following counts were made:—

| | Burned | Unburned |
|---|---|---|
| 1st pair of plots | 20 | 19 |
| | 5 | 11 |
| | 16 | 6 |
| 2nd pair of plots | 9 | 11 |
| | 7 | 9 |
| | 18 | 6 |
| 3rd pair of plots | 6 | 22 |
| | 12 | 14 |
| | 9 | 12 |
| 4th pair of plots | 13 | 22 |
| | 10 | 14 |
| | 8 | 5 |
| 5th pair of plots | 5 | 6 |
| | 2 | 4 |
| | 7 | 4 |
| 6th pair of plots | 6 | 6 |
| | 9 | 3 |
| | 7 | 4 |
| Mean for 18 samples | 9·38 | 9·8 |

Mean for all 36 samples 9·638

All figures are the number of living grubs found; no dead grubs were discovered in either type of plot. The counts were made six weeks after the grass was burned.

From a consideration of the sampling variations, the standard error of difference between the treatment means was found to be 2·8. From this figure, a "significant difference" of 7·2 was deduced. The "significant difference" is the difference which *must* be exceeded when the means are compared, if that difference is to be regarded as being due to treatment and not to chance causes.

Now the difference of the means of the two sets of eighteen samples is only 9·8 – 9·38, which is ·42 in favour of the unburned plots. If the difference had been greater than 7·2 (the significant difference) in favour of the unburned plots, then it could be concluded that the burning had had a significant effect. The actual difference found is only about one seventeenth of this, so that we may say that the burning had no effect whatever on the White Grub population under the conditions in which the burning was carried out.

It is proposed now to find whether cultivation has any effect on the White Grub population, and experiments to this end will be carried out on both burned and unburned plots.

Acknowledgments are due to the Soil Chemist for kindly analysing and working out results from the figures obtained.

**SUMMARY.**

Random counts of White Grubs were taken from burned and unburned plots to find if the burning had any adverse effect on the grubs. The results show conclusively that there was none whatever.

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# PRUNING TERMINOLOGY.

F. R. TUBBS.

Whenever a discussion upon pruning methods occurs, the need is felt for a clarification of the meaning of the various terms used to denote the different types of pruning in use. For example, the terms "skiff", "Travancore", "cut across", "brush", and "hedge" are often used to denote but one type of pruning. Even more confusing is the case where one term is used by different individuals to denote different methods of pruning. It would be extremely difficult to determine which term was used first to describe any one type of pruning and, moreover, the information would be of historical interest only.

With the initiation of pruning experiments under the auspices of the Tea Research Institute, a description of which will be found elsewhere, clear definitions of the terms that will be used when discussing them become essential. The following definitions have been submitted to several prominent planters for criticism. While it is not claimed that these terms have any historical priority over others, it is intended that they shall provide a basis for reference, whereby the experiments and their results may be more easily understood.

**CENTRING.**

The leader or leaders of a young, hitherto unpruned bush, are cut back to a pre-determined level, with the intention of causing the production of lateral branches, as a basis for frame production.

**COLLAR PRUNING.**

The whole of the above ground portions of the bush are removed, the cut being made through the main trunk at, or near ground level.

**CLEAN PRUNING.**

The main frame-forming branches are cut to the level determined upon, the greater part of the smaller shoots being removed.

**UMBRELLA PRUNING.**

A complete leafy branch is left standing above the level of an otherwise stick-pruned bush.

**RIM LUNG PRUNING.**

The centre of the bush is stick pruned, or cut across, but the branches on the circumference are left untouched or later trimmed back to a level, i.e., the bush is not cut to a uniform level in the first case.

**CUT ACROSS.**

The top of the bush is cut level about 3 in. above the last pruning cut, nothing being removed below the pruning level save diseased wood.

**TRAVANCORE.**

The bush is cut level about one inch above the tipping level, or one inch above the level of the previous Travancore.

**BAGJAN**

The bush is "Travancored" at the level of the previous cut, i.e., nearly all new wood is removed.

**SKIFF**

A high "cut across", designed to prolong a pruning cycle or to delay a rush of flush.

# PHYSIOLOGICAL WORK IN TEA.

F. R. TUBBS

During the period the Physiology Department has been in existence, contact with the industry combined with preliminary experimental work has indicated problems that need immediate attention.

First among these comes pruning. The effect of a particular type of pruning upon a tea bush will, undoubtedly, vary to a great extent according to the particular combination of jât, climate and soil that is being examined. Considerable care is, therefore, needed in applying the results of experience gained in one district to another where the combination of these factors is different. This is a difficulty common to all advisory work, but it is one that can be overcome by the establishment of sub-experiments in different districts. As a first attack on the problem, it has been decided to establish a pruning experiment on old tea at St. Coombs during 1931, and at two other centres in 1932. In order to be of direct value to the industry such experiments must answer definite questions. The primary ones it is hoped to answer are:—

(a) What is the effect of the treatment on the total yield in a pruning cycle ?

(b) Will it affect the length of the pruning cycle ?

(c) To what extent does it introduce subsidiary difficulties, such as bhanji formation etc ?

(d) Is the treatment one that can be used continuously, or must it alternate with some other system ?

(e) Is the effect of the treatment different when performed at different times of the year ?

(f) What is its effect on tannin content and on manufacture ?

Knowing the questions to be answered, it is possible to arrange a field experiment to answer them. Variations in yield with time and treatment can be examined by applying the normal process of plucking, the yield expressed as dry weight of flush being obtained by a sampling method. It has already been shown in the Agricultural Department of the T.R.I. that the systems for plot experiment worked out on agricultural crops in England are applicable to tea, provided note be taken of such additional causes of error as the variation of the standard of plucking from day to day and from cooly to cooly. It will be apparent that work such as this will not be a question of months, but of pruning cycles.

The primary characteristic of a well-designed field experiment is an arrangement such that a trustworthy reply may be obtained

to the question: "Is the difference in yield between plots subjected to treatment "A" and plots subjected to treatment "B" really greater than the differences between plots undergoing the same treatment ?" One type of layout having this character is a randomised block experiment, each treatment occurring once in each block, and its position within the block being chosen by chance.

It has been decided to examine three types of pruning in conjunction with three times of pruning in order to answer the seven questions above. Each of the six blocks will contain clean pruned, cut across, and rim lung pruned bushes, each type of pruning being performed at the end of August, the end of December, and the end of April. This may be indicated diagrammatically thus:—

| **Time of Pruning:—** | August | December | April |
|---|---|---|---|
| **Type of Pruning:—** | Clean | Clean | Clean. |
| | Cut across | Cut across | Cut across |
| | Rim Lung | Rim Lung | Rim Lung. |

This experiment will be performed on an area of 13,500 tea bushes on St. Coombs.

At this point the reader may raise the oft-recurring question "How are you to apply results from an experiment at 4,500 ft. to the problems of an estate at 1,000 ft. ?" Results obtained at St. Coombs often allow of a wider interpretation which permits their application to widely different conditions. It is anticipated that the effect of time of pruning will be of this nature, for the effects of given climatic conditions, e.g., dry weather when recovering from pruning, are not likely to vary in different places. But the effect of type of pruning is likely to be of a different nature, thereby involving its examination in different climates. For this reason two experiments at elevations of fifteen hundred feet, and of eight hundred feet have been planned to correspond with the April section of the St. Coombs experiment.

A formidable list of secondary questions could easily be formulated. In many cases it is impracticable to work these out on mature tea. For example, it is already known that a bush that is severely pruned at intervals produces a smaller root system than one allowed to grow naturally. Inasmuch as pruning of tea cannot be avoided, the question of immediate importance lies not in whether the actual size of the root is reduced, but whether pruning produces a period of reduced root efficiency. Using young tea, the dry weight of "fine roots" upon pruned and unpruned tea can be determined. This method is subject to a difficulty that has already been encountered, it being found that the rootlets remain attached to the taproot even after morbid changes have occurred. As a result

any change in the amount of *healthy* fine roots is not detectable until some time after the accompanying change in efficiency has occurred. It is believed that this difficulty will be overcome by an experiment in which the effect of pruning upon the efficiency of the roots in absorbing a manurial element, such as nitrogen, is examined.

Another large field of enquiry is the effect of pruning upon the reserves of nitrogen and carbohydrate, and the connections, if any, between fluctuations in the ratio of these and the presence or absence of bhanji formation. Work which has largely centred in America has given rise to a theory that the growth reactions of a plant may, to some extent, be bound up with the ratio of *available carbohydrate* to *available nitrogen*. Since both are essential for growth, it is obvious that in the absence of one or the other growth will not occur. But, in addition to this, the theory suggests that the varying values of the ratio found at different points within the plant are connected with the differences in the manifestations of growth at such levels, e.g., root, shoot or fruit production.

Plucking experiments upon small numbers of bushes in which the regeneration of individual shoots is followed from plucking to plucking have already been inaugurated. The results to date indicate that the regeneration of a plucked shoot is influenced by important factors at present unknown, in addition to the commonly recognised effects of manuring and of climate. Here again, it is probable that the more easily manipulated seedling material will be found of use in attacking these problems, and it is already being utilized. A further expansion of such work is contemplated in conjunction with one of the low-country pruning experiments.

The clonal propagation of tea has been attempted here, with unsatisfactory results to date. It is anticipated that fresh methods will yield better results. In this connection, it is asked that any planter knowing of cases where tea has been propagated on a large scale by other methods than seed, will give the Institute the benefit of his knowledge.

# DEFOLIATION.

F. R. TUBBS.

The first effect of the defoliation of a tea bush is to stop down the manufacturing processes which find their chief centres of activity in the leaf until such time as new leaves are put out. It is commonly believed that the damage resulting from defoliation is not confined to a temporary loss of flush, but is also to be observed in the wood growth of the bush. The purpose of this article is to set out the known facts on this subject, in view of the interest that has been displayed in the defoliation resulting from insect attacks.

The large reserves of starch and manufactured foods found in the roots of a normally healthy bush enable it to continue attempts to put forth fresh leaves in the face of steady defoliation for a considerable time. A bush was completely defoliated in August 1930, since when every bud as it appeared has been rubbed off. It is just beginning to die back from the tips of the branches after enduring a leafless state for over a year. Under these circumstances the bush is in a state of enforced dormancy, no growth of stems in thickness or length occurring.

Harper [1] examined the cumulative effects of annual defoliation of Larch by the Larch Sawfly (*Nematus erichsoni*). The cocoons hatch in May, the eggs are laid on the tips of the shoots and the resulting larvae destroy the whole leaf surface of the tree. The only manufacturing is done by a second crop of leaves just before winter sets in. As a result the tree becomes weaker and finally dies.

The annual rings of growth in affected trees were found to be narrower than in unaffected trees, while the amount of material used in the construction of the constituent cell walls was also found to be reduced. Less "mechanical" tissue in proportion to water conducting tissue was found in these trees, while in some cases additional "annual" rings were formed, showing that such rings of growth may result from other causes than the onset of dormancy.

Magness [2] showed that the defoliation of a portion of an apple tree had very little effect on the remainder of the bush, the non-defoliated portion growing normally, while the defoliated portion acted as though it was a completely defoliated tree. He found that the removal of the subtending leaf resulted in the formation of a very weak bud, which either remained dormant or only produced weak growth the next season. This latter point is of considerable interest in relation to the plucking of tea and is therefore under investigation by the Institute.

The effect of defoliation upon the growth of the apple was further examined by Proebsting [3]. He found that undefoliated branches continued to increase in thickness until the middle of July. Defoliation in May or June immediately checked the thickening, preventing any further increase in diameter during that growing season. The effect upon the microscopic structure of the wood was similar to that found by Harper for Larch, a diminution of the amount of starch stored in the twig being also observed.

It is impossible to draw conclusions from these observations that may with certainty be applied to tea. In the case of deciduous trees there is growth only during a portion of the year, growth in length and thickness being almost entirely confined to the first three months of this growing season, the remainder of the season being spent in laying down starch, hemi-celluloses etc. In tea there is a continuous growth in this climate, and it is probable that the laying down of reserves is not so markedly a seasonal process.

In order, therefore, to determine what damage to the growth of the bush may be expected from, say, a defoliation by a severe insect attack, experiments are being started in which the effect of defoliation for varying periods upon wood growth and flush will be examined.

(1) Harper, A. G.—Ann. Bot. 27, p. 261, 1913.

(2) Magness, J. R.—Bull., Oregon Agr. Coll. Expt. Sta., 139 pp. 46-77, 1917.

(3) Proebsting, E. L.—Hilgardia, 1, 5, 1925.

# THE INTRODUCTION OF TEA INTO CEYLON.

F. R. TUBBS.

Details regarding the introduction of tea into Ceylon will always be of interest. The following extracts are obtained from the Annual Reports furnished by Dr. G. H. K. Thwaites, while Director of the Royal Botanic Gardens (1857-1880) by courtesy of the Curator, Royal Botanic Gardens.

1859.—"If it should be thought desirable to establish an Experimental Garden on the Hills, for the purpose of cultivating the quinine plant, other important objects might be carried out at the same time, which cannot possibly be effected at this inconsiderable elevation. . . . The Tea plant might have a fair trial given to it, not as regards its successful growth, but as to a cheap mode of its propagation."

1861.—"We are in a position to be able to furnish, from the numerous plants now in this garden, a considerable quantity of tea seeds, should they be required for experiments in the cultivation of this plant in the Island."

1862.—"The supply of seeds of all kinds for distribution has been well kept up, and Tea, Tobacco, flower and vegetable seeds have been sent out in some considerable quantity during the past year."

1866.—"The disposition amongst planters to attempt the cultivation of tea to some considerable extent in the Island is becoming more and more decided, and it has been determined that an experienced planter shall proceed under the auspices of the Government and on a mission from the Planters' Association, to inspect and report upon the cultivation and preparation of tea as carried on in the Tea Districts of India. At the request of the Planters' Association I have drawn up a paper of suggestions as to the points upon which attention should be particularly directed and information obtained, laying much stress upon the importance of ascertaining, by observation of facts connected with the gathering of the leaves and the quality of the produce, whether the difference of climate, necessarily obtaining on account of the difference of latitude, between Ceylon and the Tea-Producing Districts of India, is likely to operate disadvantageously in Ceylon as regards the profitable cultivation of Tea."

"In addition to the information likely to be obtained from India, it would be very desirable to get, if possible, trustworthy accounts of the cultivation of tea in Java, which possesses a climate so similar to that of Ceylon; and I would take the liberty to suggest

that an application from this Government to that of Java would probably result in our being favoured with valuable communications on this subject."

"An advertisement having, at my request, been inserted in the Government Gazette, stating that small quantities of Tea seed would be given to planters applying for the same for the purpose of forming nurseries of the plant, I have the pleasure to state that all our available seed was applied for, and since my last report more than two hundred pounds in weight have been in this way distributed. Our trees are likely to produce a fresh crop of seeds before very long, and we shall have a much larger supply to send out when the numerous young plants here and at Hakgala commence to bear seeds."

1867.—"The interest felt by Planters in the subject of Tea Cultivation in the Island, has been unequivocally shown by the circumstance of a considerable amount having been subscribed towards paying the expenses of a gentleman commissioned by the Government to proceed to the tea districts of India, for the purpose of acquiring information to enable him to report upon what is most essential to be known with reference to the cultivation and preparation of Tea in those districts. This gentleman has returned to Ceylon, and his interesting Report has been printed at the Government Press. It embodies much valuable information, and is very full on the important subject of the amount of labour required upon a tea plantation and its average cost. It will no doubt be referred to with much advantage by those who may feel inclined to embark in the cultivation of tea in Ceylon."

"The Tea plants at the Hakgala Gardens, amongst which are a few of the Assam variety, are growing vigorously. I have written to the Superintendent of the Calcutta Botanic Garden, asking him to be so obliging as to send me a case of plants, as well as a supply of seeds, of what is called the Hybrid variety, which is considered in India to be the kind most desirable for cultivation."

"A good many Tea seeds have been distributed during the past year."

1868.—"There is every symptom of the cultivation of this plant being taken up with some spirit before long. Some Tea sent to England, which had been prepared by a Planter from the ordinary China Bohea Tea plants, was thought highly of by the London Broker, and it is believed that the samples referred to can be easily improved upon. I hope that arrangements will be made before long for the instruction of some intelligent natives in the Establishment and elsewhere in the Island, not only in the proper management

of the plant under cultivation, but also in the proper mode of preparing the different kinds of marketable Tea. There are now several localities in the Central Province where there are a good many tea plants which could be experimented upon, and the number of localities will no doubt before long be greatly increased."

"I am expecting to receive very shortly from the Calcutta Botanic Garden, by direction of the Indian Government, a supply of seed from the Assam Hybrid Tea, which I propose to distribute in certain quantities to Planters, who will undertake to raise and cultivate the plants carefully, and if called upon to do so, to furnish this Establishment, when their plants are sufficiently old, with similar or larger quantities, as may be agreed upon, of ripe seeds for our further distribution. The seeds of this variety received some months ago from Dr. Anderson, having been sent in moist earth in a close glazed case, all germinated, and young plants raised from them are now growing vigorously at Hakgala, and a few in this garden. Some plants of the Assam tea, which came in the same case, are all growing exceedingly well at Hakgala. This latter variety does not appear to succeed at so low an elevation as that of Peradeniya, and the plants we had here have all been sent to Hakgala, where they quickly revived from their weak appearance."

1869.—"The small plantations at Hakgala are growing most vigorously, and will be gradually increased, to enable us to supply demands for seeds, which it is generally expected will by-and-by be made for them."

"Seeds of the common China tea can now be supplied from Peradeniya and Hakgala in considerable quantity, and before very long I hope that the Hakgala plants of the Assam and of the Assam Hybrid teas will be producing seeds abundantly."

1870.—"The small plantations of tea both at Hakgala and at Peradeniya are in flourishing condition. An abundance of seed is being produced upon the trees; and at Hakgala moderate supplies of seed of the Assam Hybrid variety can be had, if applied for by persons wishing to form nurseries of this valuable kind upon their estates. The tea plant thrives so luxuriantly upon our hills, at an elevation slightly above that suitable for Coffee cultivation, that it is difficult not to believe that their slopes will before very long be covered with thriving tea plantations."

1871.—"Both in this and in the Hakgala Garden the different kinds of tea are propagated to some extent for the purpose of supplying seeds to persons applying for them, and who will undertake to sow them, and to cultivate carefully the plants raised from them Tea seems to be slowly getting into cultivation here, and I am glad

to be able to announce that an experiment on a tolerably large scale, and with the proper appliances, is about to be made in the preparation of the leaves by one of our principal planting firms. It has been suggested that, as there are several plantings of tea on different estates, it might be desirable to obtain from the Assam Tea Districts two or three respectable men who are experts in manufacture of tea suitable for the English Market. These men might instruct a certain number of planters and intelligent natives in the proper system of preparation of the tea, from picking the leaves to their being ready for exportation as the finished article of commerce."

1872.—"The cultivation of tea is making rapid advances in the Island. The manufactured article is pronounced to be of excellent quality. It makes a bright clear infusion, is fragrant and palatable. The Assam Hybrid variety, which was introduced into the Island a few years ago, grows most luxuriantly both in this garden and Hakgala, although the difference of elevation is more than 3,000 feet. Of this kind, which is most in demand, additions to our plantings are being made as rapidly as possible, with the object of the production of good supplies of seed for distribution, as imported seed cannot be so well depended upon for germinating as that recently gathered from the trees. Of the ordinary China tea, a great abundance of seed can now be procured from either garden."

1873.—"The cultivation of the Assam Hybrid variety is getting rapidly into favour, and but for the comparatively small number of plants and seeds procurable in the Island, added to the difficulty of obtaining from India really good seeds for germination, tea cultivation would advance more expeditiously here. There cannot be the least doubt, however, that these difficulties will not long operate as a check, the climate of the Island being so admirably adapted for tea-growing. The Assam Hybrid variety grows equally well at Peradeniya and at Hakgala, and our plantations at both places are being considerably added to, in order that we may be prepared by-and-by to issue fresh seeds in large quantity. Of the ordinary Bohea type of China good supplies at a very moderate charge are obtainable at both our gardens. I would strongly recommend trials being made of this hardy plant on abandoned coffee estates, rather than that weeds should be allowed to take possession of the land. There can hardly be a doubt that the expense of such a step would be more than repaid, if tea is one day to become, as it most probably will, one of the most important staple products of the Island."

1874.—"Cultivation is progressing most rapidly in the Island. Extensive clearings of forest land have been made in different directions for forming plantations even up to considerable elevations upon the hills. Planters are generally obtaining their seeds from India, but a good many plants and seeds of both Assam Hybrid and China teas have been distributed during the past year from our two gardens. The plantings of the Assam Hybrid kind are being extended both at Hakgala and Peradeniya, in order that good seeds may be available for distribution to those not willing to incur the risk of getting so perishable a seed from India."

1875.—"Supplies of seeds and a few thousand plants have been sent out during the year from Peradeniya and Hakgala, but planters generally, notwithstanding the risk of transport of so perishable a seed, would seem to prefer getting from Assam seeds for the numerous plantings now being made in the Island."

"It is now a well-established fact that commercial tea of a very superior quality indeed can be produced in Ceylon."

1876.—"Tea plantations are rapidly making themselves visible in the upper portions of many of the Hills of the Central Province. The shrubs exhibit a very healthy appearance. The Assam Hybrid variety is in most favour for planting, and there is very little demand for the ordinary Chinese kind."

1877.—"Tea cultivation is progressing rapidly in several districts of the Island, and at different elevations. As it is so well understood that a very superior finely flavoured tea is capable of being produced in the Island, planters are doubtless giving their best attention not only to encouraging the luxuriance of the trees, but also to ascertaining the very best mode for the preparation of the leaves. A large number of plants and seeds have been distributed from this garden."

# SOIL EROSION: THE PRESENT POSITION.*

T. EDEN.

## INTRODUCTION.

I have chosen to talk to you on the subject of Soil Erosion because I believe that the present is a critical time from the point of view of that important subject. You are all of you doubtless conversant with the findings of the Committee, and it is unfortunate that financial stringency, both in governmental and planting circles, has prevented a forward move in keeping with the major recommendation. Even the most whole-hearted supporter of the anti-soil erosion movement has at present to consider carefully plans for immediate extension of the work, whilst to the unbeliever the economic situation acts as a balm to any heart burnings he may have had.

I fully realise the difficulties, but at the same time I feel that it would be a thousand pities for the movement to hang fire and for enthusiasm to be damped entirely by present conditions. In soil erosion work there can be no standing still: we are either moving forward or backward, and the least we can do is to maintain what the sailor would call steering way.

I have come here today not only to give you my views, but also to hear yours. The Tea Research Institute has no desire to consider the subject *in vacuo*, and I welcome the chance of discussion that this meeting affords.

## THE PRESENT POSITION.

As far as my own observations go I agree with the report that there is little fundamental opposition to the principle of combating soil erosion. To draw an illustration from the ills which are afflicting the world at large, and the home country in particular, few people deny the seriousness of the position, but all the argument rests on how to get over the difficulty.

The report advocates cover crops, and from a fundamental point of view there is no doubt that cover crops offer the completest solution of the problem. There is no harm in repeating what I have said elsewhere that the only way to prevent soil movement on steep slopes is to immobilise the soil, and, by encouraging humus, to increase the soil absorptive capacity for water. There is a limit for every surface soil to the amount of water it will retain in the pores, and when that limit is reached the resistance to the movement of one soil particle over the other is very much decreased. Cover crops fulfil the desired checking function better than any system

* This paper is the substance of a lecture delivered before the Sabaragamuwa Planters' Association on Oct. 16th, 1931.

of high or medium shade. The only thing I have seen which approaches them in efficiency is a very thorough mulch of Grevillea leaves.

## DIFFICULTIES OF COVER CROPS.

There are, however, grave difficulties about the use of cover crops and it is with these I wish chiefly to deal today. I have no wish to minimise them, but I think that they are sometimes over-emphasized. My aim will be to point out what I believe is the best way of approaching the problem with a view to getting over the obstacles.

The first difficulty is to get a cover crop to grow at all well. A superficial examination of the problem might lead one to divide growers of cover crops into two classes: those who spend all their efforts in nursing the crop, and those who spend their time fighting it. I shall deal with the latter group later, but there is no doubt that large numbers of estates find it difficult to establish their would-be cover crops. The resolution of that difficulty, is I think, a matter for an institute such as the Tea Research Institute. It involves the testing of as many promising varieties as possible. We are already doing something in that line and we propose to do more. The type of cover which has hitherto found most favour is the leguminous crop, because of the contribution to soil nitrogen that the bacterial nodules on the root make. Now it is a well-established fact that those root nodules are as necessary to the plant as they are desirable to the planter, and the possibility has to be considered whether the soil naturally contains sufficient bacteria *of the right type* to produce a healthy young plant able to resist the severities of the climate at the most critical time in its life. It may be known to you that, in other countries, crops like lucerne have been grown successfully on what had hitherto proved unsuitable land, and the acreage manifoldly increased by the expedient of inoculating the seed before sowing. The process has been reduced to an extremely simple routine operation and put on a commercial basis. In England last year some 4,500 acres of new land were brought into lucerne cultivation in this way. I shall not elaborate this because the detailed problem, as it affects tea green manures, is in the hands of Dr. Gadd, but I wish to show you that our Institute is alive to the problem and desirous to implement the recommendations of the report.

## CONTROL OF COVER CROPS.

The second difficulty is the problem of control of cover crops, and that is a subject upon which I feel the estates themselves can do the most useful work. The cultural cycle of tea varies so much

from district to district, and even from estate to estate, that set and formal experiments at a place like St. Coombs are not calculated to give anything except a fraction of the information desired. The control of green covers would probably involve the alteration of estate routine to a greater or less extent. It is for you to decide whether weeders can be trained successfully to do the work, or whether the estate itself will have to organise a new branch of workers. In the long run it comes down to a question of cost. As the report says, the control of shade is a recognised procedure and is regarded as a legitimate expenditure, and ultimately cover crops will have to be put onto a similar footing. I personally feel that there is no greater or more important contribution that the planting community can make than to try out with an open mind the question of control of cover crops. It is a job that nobody else can do. All the departments of agriculture and tea research institutes in existence cannot on this particular problem provide half such important data as you yourselves can. If you could see your way to trying covers out on one division with a thorough costing of the control, and if some of you can show us the most economic and least disturbing way of doing it, that would be a tremendous contribution to the spread of anti-erosion methods. It calls for some persistence and imagination, but I am convinced that it is worth giving a thorough trial.

## COMPETITION BY COVER CROPS.

The third difficulty, or rather objection, lies in the competitive activities of cover crops. That this takes place to some extent must be allowed, but against this must be placed the ultimate benefits conferred by the cover crop and the fact that the two crops, cover and tea, are exploiting different soil zones. As far as nutrients are concerned there does not appear to me to be any justification for drawing any distinction between ground cover and shade, in fact the advantage seems to be with the cover crop. Leaving out of consideration for the moment the nitrogen fixed by the root nodules, cover and shade are both drawing appreciably on the soil for nutrients. Now in burying loppings of dadap for instance, there is a great bulk of woody tissue rejected in addition to the tree trunk. All this woody tissue contains nitrogen, but because the *concentration* of nitrogen in this tissue is small it is inadvisable to bury it. Tissues containing less than about 2% of nitrogen provide, when buried, no readily available nitrogen for use in the soil and tend to lock up temporarily existing soil supplies. This is a sufficient reason for not burying woody matter, but it does not lessen the loss of nitrogen caused by this removal of wood, containing, in the aggregate, large

quantities of this valuable nutrient. The argument for using loppings is that despite the loss in wood the system of returning green stuff to the soil and growing more green stuff is still more economical than cutting out green stuff altogether. The point I wish to make is that shade trees compete just as much as cover crops and that the losses of nitrogen in woody tissue is greater proportionally in shade trees than in cover crops. If you compare a clean weeded soil with one on which a cover has recently been established, you may find a drop in crop in the latter, but if you proceed with your cover and fork it in, thus conserving soil and humus, you put a period to that loss in crop, whilst the unprotected soil proceeds literally and metaphorically down the incline of capital loss.

There is one other point that I should like to mention, namely the efforts that should be made to put on an experimental footing the observations on types of drain referred to at some length in the report. One looks forward to the time when new openings of tea will be a practical proposition again, and the first question that arises is what type of drain to use. It is to be hoped that the old open drain is a relic of the past, and moreover that, where possible, existing drains will be converted into types designed to resist soil movement rather than encourage it. In order to clarify the position we have on St. Coombs laid down a number of drains, some plain and some open, some bunded, and some with a reverse slope. Half of these receive drainage from areas that have been burned before forking the patna, and half from plots where the patna was forked without burning. In the heavy rain storms of the N. E. monsoon measurements of water delivered into these drains will be made at intervals of say half an hour. For the time intervals we shall naturally have to be guided by circumstances. At the same time an automatic rain gauge will give us accurate measurements of the rainfall in the interval, and samples of the turbid drainage water will provide a measure of the amount and type of soil removed. Not only shall we be able to get detailed data on how these drains do their work, but on how the type of opening affects the water absorption and water delivery. Especially interesting will be the behaviour of the soil after very dry periods, compared with its behaviour when the soil is already moist, and also the effect of recent cultivation. Hand in hand with these measurements will go analyses of the soil for loss of nitrogen and humus, so that eventually we shall hope to have a comprehensive picture of a good many of the factors which contribute to, or prevent, soil erosion. Only by some such means can the value of soil erosion schemes be rapidly and accurately assessed.

# ANALYSIS No.—? WEEDING.

GEORGE BROWN.

I see the Director of the Tea Research Institute, in his report for 1930, welcomes articles for *The Tea Quarterly* Journal—so as there was a reference in the May number to the findings of the Commission on Soil Erosion, I venture to make so bold as to plead in a short article that Analysis No.—? Weeding (that Analysis Number that has frightened so many of us) may be looked at from a new angle, and, though doubtless my critics will be many—yet it may lead to a little further interest and possibly progress in this very vexed subject. Now, I don't intend to outline the history of clean-weeding as carried out generally on Tea Estates in Ceylon, because we all of us know more or less its history, and how positively anathema a dirty looking estate is to a Superintendent to see daily, to a V.A. to visit, to an Agent to write about, and to a Director to discuss.

Personally, to me as a planter, clean-weeding, as such, seemed to be at times almost a V.A.'s shibboleth; but yet, when one became a V.A. oneself, one found, with conditions as they are, it was unsafe to dispense with this shibboleth; for, should the weeds on an estate get out of hand, all of us know the trouble and worry and terrible cost it entails to clean the property up again. Well then, let us get to the point:—Weeding, or shall we say clean weeding, as regards agriculture generally, it goes without saying, is right—provided it is not carried out, at the expense of the top-soil, or the main crop's food. Thus, it logically follows that if a weed is removed from any crop, unless that weed contains within itself some particular form of poison noxious to the main crop, that weed should go back, or be buried again in the soil from whence it came. If it is a noxious weed it should be burnt, and its ashes should be returned to the soil from whence it came. Provided this happened and no soil were to be lost in the process of removal, then this I take it would be ideal from the main crop point of view.

Now in Ceylon, under Analysis No.—? Weeding, there are at least there different works going on, which are charged to weeding, and which in two cases are *not true weeding*, and should be charged up otherwise; and if this were done, I maintain the whole of our present system of weeding would be altered, and put on a much more scientific basis.

Supposing the operation now called weeding were to be treated as follows:—

(1). All noxious weeds, such as grass-weed, creepers of all sorts, and extraneous jungle growth, should be regularly taken out of the tea and burnt, the ashes being returned to the soil, and this work should be charged to *Analysis No.—? Pests.*

(2). All tall, and most flowering weeds, should be removed by hand and buried, and this work alone should be charged to *Analysis No.—? Weeding.*

(3). All low growing leguminous plants, and certain other kinds too, such as oxalis should when necessary, be forked into the soil, and this work should be charged to *Analysis No.—? Green Manure.*

The above treatment and accounting would send the cost of Pests up, but the cost of Weeding, as such, should go down. The removal of Plant Pests of all sorts would be much more thorough and systematic, if entirely divorced from weeding, than it is at present on many properties where both works are treated as one, and left to the weeding contractors, or weeding gang; and again by hand-pulling of weeds only, very little top soil would be disturbed and lost. As to the third item, "Green Manuring", the cost of this would tend to go up, but it would be adding to the value of the property, and to the fertility of the soil.

The great outstanding gain would be very little loss of soil, compared to the loss caused by the present, to my mind, confused methods. Now, I realize only too fully the cost of re-claiming a dirty property, (a cost of cash, and a cost of top soil,) and I would certainly not advocate a general change, wholesale, from present methods of weeding, but I think it is possible and indeed probable, that some estates might try this method on certain divisions, if indeed, judging by certain indications, they are not doing so already. The method might be tried on a division for a couple of years to test cost and appearance—perhaps I ought to use the common word "dirtiness" instead of "appearance", for, it must remembered that should a thorough advocate of clean-weeding observe any foreign plant growing on an Estate, leguminous or otherwise, to such a person that estate at once assumes a dirty appearance. To my mind however, appearance is of but little consequence, provided the foreign plant is not deleterious to the main crop.

Grass weed of any sort is bad, and worse than bad, on a Tea property but I would ask any careful planter—how many weeding contractors could he trust by themselves to remove a grass weed correctly with a weeding scraper, that is to remove it root and all, and to put it in a cutty-sack, and at the same time to cause no appreciable soil erosion in the process ? A Pest gang armed only with small hand-forks, and told off for this special job, would, I think, approach much nearer perfection. To sum up, as regards expenditure, the enhanced cost of Pests would be set off by a less cost of Weeding, and the capital of the estate, i.e. the Top-soil, would be conserved.

# BOOKS ON TEA.

## (REVIEW.)

### (1). TEA PLANTING IN CEYLON.

[By Messrs. E. C. Elliot and F. J. Whitehead. 2nd Edition, 1931. The Times of Ceylon Co., Ltd. Colombo.]

The agricultural chapters in the second edition continue to give a very useful account of the whole process of tea cultivation such as any beginner will value. The balance, so difficult to obtain in a book of this type is, it appears to us, very well maintained and the authors have on the whole avoided any undue stressing of their personal views. Some new matter has been included, amongst which may be mentioned the provision of diagrams of several methods of drain construction. Both in this section and that devoted to green manuring we should have welcomed an extension of the space dealing with the harmful effects of soil erosion. We cannot suppose that the authors are unmindful of it, and in a book which will and should be widely read such provision would be doubly valuable.

Without seeking to detract from the very great usefulness of the book, there are a certain number of misconceptions in it which should not be allowed to gain general currency and which ought to be corrected in future editions. There appears to be some confusion in the matter of the function of green manure plants. In more than one context mention is made of the amount of nitrogen *added* to the soil by the burying or forking in of green manure loppings. On page 98 the argument culminates in the following sentence: Where green manuring is carried out on a liberal scale it should become possble in time to reduce the proportion of nitrogen providing constituents in artificial fertilizers *and under specially favourable conditions possibly to discontinue their inclusion altogether.*" The italics are ours. This is a forlorn hope. Considering first non-leguminous crops, the whole of the nitrogen provided by green manure loppings is nitrogen derived from the soil and the soil only. To fork in a quantity of loppings each year containing say 20 lb. of nitrogen is not equivalent to adding this amount to the soil on each occasion. This nitrogen is temporarily withdrawn from circulation by the green manures during growth and is held as it were "on deposit", to be returned and rendered current by degrees when the loppings are incorporated in the soil. It is not a new supply; it does not contribute anything to the capital account, and is not on the same footing as the addition of 20 lb. of nitrogen in the form of fertilizers. To say this is not to disparage the usefulness of green manure

loppings even from the point of view of nitrogen supply, for whilst it cannot *create* nitrogen it does *conserve* it. Where leguminous green manures are used there is a potential source of new capital from bacterial nodules on the roots but the amount thereby added is in our present state of knowledge problematical under tea planting conditions. In the same connexion there is no justification for the statement (page 30) that when weeds are forked in, only some of the nutrients they contain would be returned.

On page 72 there is a serious misprint. The text reads: "The action of the denitrifying organisms is just the opposite of that of the nitrifying and nitrogen fixing bacteria, for instead of *nitrogen* being added to ammonia to form nitrities and then nitrates in the soil, by their action *nitrogen* is acutally abstracted from nitrates and ammonia formed from it." The italicised "nitrogen" should in both cases be oxygen.

Passing to pruning the necessity for this is explained as due to a deficiency of sap. We do not think there is any evidence to support this nor the statement that the material removed at pruning is superfluous to the plant.

Emphasis is rightly laid on the necessity for lighter pruning and for preserving an ample number of branches on every bush, but the reason given for this seems to be based on a misconception. Actually the branches themselves contain but little reserves of starch and sugar which are stored in the roots. If, however, sufficient leaves be left on the bush, the latter can continue to manufacture carbohydrate material and there is a greater chance of rapid recovery than where new growth is dependent on the root reserves only. It is disappointing to find no reference to the importance of lighter pruning and adequate food reserves in relation to the occurrence of the so-called Diplodia disease. The work of Gadd in this connection has been amply confirmed and is now widely known.

The question of wound gum, callus, and the effect of pruning mixtures is not sufficiently elucidated to justify the confidence expressed on pages 56 and 83. It is certainly incorrect to say: "*Cut surfaces thus sealed (by wound gum) are protected against the entry of fungus spores and disease germs generally, even though the layer of callus has not completely covered the cut. This fact explains why pruning cuts once circled by a ring of callus do not decay although complete healing may not be secured for years.*" The Institute's Annual Report for 1928 (page 13) gives an excellent example of a case where callusing is complete with advanced wood rot beneath. The occurrence of wound gum in tea has, moreover, yet to be proved nor, assuming its existence, has manuring been demonstrated to have any influence on its production.

In comparing the relative advantages and disadvantages of light pruning reference is made to the *slower* growth after light pruning. Our experience has, however, been that the reverse takes place, growth in such cases being more rapid. Data relating to this subject will be found in the paper on "Pruning" read at the Institute's last Conference (*T. Q.* 1931.).

Passing on to the section on Pests and Diseases the only new matter relating to fungus diseases deals with the fungus Rhizoctonia bataticola. Diplodia disease, so-called, is included amongst the parasitic diseases though, as has already been mentioned, it is now well established by the work of Gadd that this results entirely from a deficiency in the internal food reserves. The use of lime is recommended for the treatment of fungus root diseases though its value is very problematical and in some cases may be definitely harmful.

Amongst insect pests, Tortrix, Shot-Hole Borer, Termites and the Mosquito Bug are cited as the principal insect pests and no mention is made of Nettle Grub now so troublesome in the Uva district. With regard to Tortrix there are many who doubt it may be responsible for the destruction of 150 lb. made tea per acre in one year. Statistics in support of this view would be of value. It is also doubtful whether the statement that the distribution of Tortrix is principally effected by wind can be sustained.

Manuring as a remedial measure against Shot-Hole Borer is rightly indicated but attention might usefully have been called to Bulletin No. 78 of the Department of Agriculture which is full of information on the subject.

One surprising omission from this section is that no reference is made to the Paris Green treatment for Termites. This treatment would appear to offer the only practical method at present available for dealing with *Calotermes militaris*.

The chapters on manufacture give an excellent account of the various processes involved, the section on withering being particularly detailed and instructive, and including a useful account of the theory of air conditioning. As might be expected, considerable space is devoted to the subject of artificial withering and the authors rightly point out that many of the defects commonly ascribed to artificial withering are avoidable and due to imperfect control of this process. The "Reversible Withering" system is explained in detail but no reference is made to the somewhat similar "Alternating Withering" system.

The book concludes with very useful and practical chapters on estate buildings, machinery and labour.

Altogether the book is a most useful contribution to the literature of tea, it is well produced and printed and the diagrams are clear.

If attention has been called to certain misconceptions in the more theoretical sections, this is in no way intended to decry the general value of the book which we trust, will enjoy a large circulation. The fact that the volume will be widely read makes it the more desirable, however, that such errors should be rectified in the next edition.

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## (2). "TEA MANUFACTURE, ITS THEORY AND PRACTICE IN CEYLON."

[By H. J. Moppett. Second Edition, 1931. The Times of Ceylon Co., Ltd.]

This book, as its title indicates, has a more limited scope than that reviewed above, dealing with manufacture alone. Speaking generally, a very clear account is given of the various processes of manufacture and the book contains much practical information of value. On the theoretical side, however, there are several statements which invite comment. The author states quite frankly in his preface that, pending more definite information, he prefers to adhere to the older views put forward to explain the changes taking place during manufacture in spite of the criticisms which have been passed on some of these theories. With such a decision one is not entitled to quarrel, though one may perhaps feel a doubt whether the fact that a satisfactory new explanation may not be forthcoming is an adequate reason for continued acceptance of theories which in some cases can be shown to rest on no certain foundation. In view of the present uncertainty regarding much of the theoretical side of manufacture one cannot but feel that the book would not have lost in value if some of the theoretical discussions had been omitted.

The advances made in withering practice since the first edition was issued have been fully dealt with in the present edition and a good account with appropriate diagrams is given, explaining both the "Reversible Withering" and "Alternating Withering" systems.

As regards the changes taking place during withering one must challenge the statement that there is any increase in tannin in the leaf during withering. There is also much doubt as to whether there is any real "development" of the leaf enzyme. The apparent increase in this is probably explained by the fact that owing to the physical changes which take place during withering, the leaf cells are rendered permeable and, in consequence, the intermixture of the enzyme, already existing in the leaf, with the other cell constituents is facilitated when rolling takes place.

The section on rolling contains much useful advice of a practical nature and the various rolling programmes given should be of assistance to those wishing to work out the right conditions for their particular case. One is glad to see attention called to the placing and type of battens, as there seems to be a tendency to use battens of too drastic a type, which effect too much "cutting" at the expense of "twist".

Fermentation is described in some detail and the importance of proper humidification and ventiliation very rightly stressed. On the theoretical side the author evidently prefers the theory that fermentation is brought about by yeast-like organisms. In the opinion of the writer there is little reliable evidence to support the view that such organisms are responsible for the primary fermentation, though they may be concerned in secondary changes which may possibly have some influence on quality. Tea leaves, like most other vegetative cells, contain oxidising enzymes and these are brought into contact with the tannins and similar compounds, all compounds of a highly oxidisive nature, when the leaf is rolled.

It hardly seems necessary in these circumstances to invoke the aid of extraneous organisms for the provision of the necessary oxidising enzymes. Yeasts no doubt are found in fermenting tea—they occur widely on plant leaves—and will increase in number during fermentation but this is no evidence that they are the primary agent of fermentation.

The use of electrolytic chlorine as a sterilising agent for fermenting rooms is suggested. Normally, under the conditions which obtain in a Ceylon factory such a strong disinfectant should not be required. Should, however, persistent trouble with taints indicate the necessity for more vigorous cleansing E. C. in acid solution will prove effective. E. C. stabilised with lime should not be used, nor other alkaline disinfectants, and a liberal wash down with plenty of water is essential.

In the section on firing it is disconcerting to see the statement on page 59 that 180° is the minimum temperature to which the leaf should be subjected at the commencement of firing. In a strong current of air fermentation is quickly arrested at considerably lower temperatures. The desirability of an initial temperature as low as feasible is obvious when one considers that it is at this stage, when the leaf contains a high percentage of moisture, that the greatest loss of essential oil takes place.

Stewing must naturally be avoided but a very large number of tests suggests that an exhaust temperature of about 120°, with an

inlet temperature of 185-195°, gives good results in most cases. The fermentation can be rapidly checked under the above condition, using reasonably thin spreading and high fan speeds.

When the tea is initially exposed to high temperatures there is considerable risk of case-hardening which results in teas of poor keeping quality. There is no question that case-hardening is very prevalent in Ceylon factories and this defect is much more often the cause of teas being reported on as soft in London than underfiring.

A much-needed warning is given on page 60 where figures are quoted showing the rapidity with which fired tea absorbs moisture if left lying in the open. Considerable damage is caused in many factories by unnecessary exposure.

The book is attractively produced with a number of excellent photographs and diagrams, and gives in the short compass of about one-hundred pages a full and quite comprehensive description of tea manufacture which should be much appreciated by Planting Students and others interested in the manufacture of tea.

ROLAND V. NORRIS.

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# SOME ASPECTS OF TEA MANUFACTURE.

B. N. SASTRI.

During the past nine months I have had occasion to visit a large number of tea factories in various parts of the Island to examine the conditions of manufacture. These visits have given me a good opportunity to study variations in factory practice, and it is my intention in what follows to comment on a few of my observations.

It is generally known that the quality of tea is connected with its tannin content. Leaving aside those teas which sell mostly for their flavour, a fairly close relationship is found to exist between tannin content on the one hand and quality on the other. In the present state of our knowledge we are justified in stating that quality is connected more with the tannin than with any other constituent of the tea leaf, although modifying effects are introduced by the non-tannin substances. Chemical analysis shows that the younger the leaf the more tannin it contains. On this basis it is evident that where quality is the prime consideration, the use of coarse and overgrown leaf is detrimental, and the plucking rounds should be adjusted so as to avoid over maturity of the flush. Some of the other factors influencing tannin control have already been discussed in previous publications of the Institute.

It will be sufficient to state here that the amount of tannin present in the pluck varies with the season of the year and the conditions of growth, in other words with the physiological state of the bush. Thus leaf from a freshly pruned field is very poor in tannin and an experiment conducted on an up-country estate indicated that it was not till after the fifteenth round that the leaf regained its normal state. Again, as a general rule, rapid growth is followed by a flush of poor tannin content. Shade is also not without influence and, while moderate shade is beneficial, heavy shade may be detrimental to quality.

It is well to remember that tea manufacture commences from the moment the leaf is plucked and the greatest care is necessary in handling the pluck if serious damage is not to occur before the leaf even reaches the factory. Bruising is the most common fault, being frequently found where wireshoots and ropeways are employed without proper precautions being taken to minimise the force of impact at the receiving station. The importance of avoiding bruising will be appreciated if it be realised that when this occurs, the enzymes or ferments present in the leaf are brought in contact with the other cell constituents and premature fermentation is set up. Such leaf will, therefore, invariably be irregularly fermented with resulting loss of quality. Another far too common fault is overheating, owing to the leaf being packed too tightly in the plucking baskets or allowed to remain in heaps before being spread on the tats. Owing to the fact that respiration is taking place in the leaf, there is a considerable production of heat and the temperatures attained in leaf baskets or leaf heaps is much greater than is usually appreciated, and may be a cause of serious damage.

Carpenter and Harrison have shown that at high temperatures the leaf becomes reddened due probably to chemical changes in the tannin. At a temperature of 138°F. this change may occur in 10 minutes, whereas at 115° more than three hours is required. The importance of keeping the leaf cool is therefore obvious.

**WITHERING.**

It is not within the scope of this article to deal with the details of withering arrangements but only to discuss certain general considerations. Attention must again be directed to the risk of bruising the leaf while this is being spread on the tats, this often occurs owing to the leaf being trampled on by the coolies or by unnecessarily rough handling.

The two essentials of withering are firstly, to secure conditions which lead to an even and uniform wither and secondly, to turn out from day to day leaf of approximately equal moisture content. Loss

of moisture during withering occurs principally from the leaf surface, moisture from the stalk diffusing through slowly to the leaf. If the loss of moisture be too rapid, as when the atmosphere is too hot or dry, the leaf dries up and may even become black, while the stalk is still insufficiently withered. At the same time the young buds also become dried out, leading to a greying of the tips. Such conditions not infrequently occur when artificial means of withering are used without adequate control. In such cases temperatures in the neighbourhood of 100° may be encountered, particularly round those tats close to the hot air intake. Rapid withering at high temperatures results in mottling of the leaf and is highly detrimental. Provided, however, that proper precautions are taken there is little reason why artificial withering should not give approximately as good results as natural methods. The use of warm air should be restricted if possible to the removal of the surface moisture in the early stages of withering and should not be used to force a wither in the later stages. The latter practice leads to too rapid drying of the leaf surface, leaving the interior still too moist, in other words the condition of the leaf is not homogeneous. Quite frequently it should be possible to secure a wither in a reasonable time by employing the fans without using hot air from the driers. A greater movement of air through the loft is obtained in this way without the disadvantage of high temperatures and it is a practice which might be more frequently utilised.

Owing to the high resistance met with when air has to pass the whole length of a long loft, the fan capacity must be ample and sufficient to replace the air in the loft at least every two minutes. The fan capacity should also be related to the capacity of the drier fans and the bulking arrangements such that proper admixture of hot and cold air in the required proportions can be attained. Very frequently one finds the fan capacity limited by the narrowness of the inlets to the fan chambers and from the fan chambers to the lofts. In such cases pockets of stagnant air will be found and the wither will be uneven. It is needless to say that all lofts should be equipped with hygrometers so that the temperature and humidity of the air being used is known.

In some factories tats are employed with too steep a slope, sometimes as much as 1 in 6. Such tats offer a very high resistance to air movement and are a frequent cause of trouble, particularly when facilities for reversible withering are not available, the air passing through the loft too slowly to secure an even wither at the two ends. Temperature and humidity condition should be as uniform as possible throughout the loft and this is more easily attained if tats with a slope not exceeding 1 in 18 or 20 are employed. The leaf

should be withered down to a definite water content. This is the first step in standardising manufacture, since if this be done rolling, fermentation and drying will take place under definite conditions. The usual system employed is to wither the leaf to a definite loss of moisture after applying a correction for the "wetness" or external moisture on the leaf. This correction will vary within wide limits and, being difficult to assess with any accuracy, this method leads to very varying withers. If no correction for wetness be made and the leaf is withered to a constant moisture content, the degree of wither as conventionally expressed will naturally vary considerably at different seasons and this figure has really little meaning. Thus if a 50% output on made tea to *withered* leaf is aimed at, the degree of wither might be 56% on a dry day or 36% on a wet day, the output of made tea on *green* leaf being 28% and 19% respectively. Although these figures are so different, the condition of the withered leaf on the two days in question would be the same in its relation to rolling, fermentation and drying. It would on all grounds seem preferable to abandon the present system of expressing withers and to control the uniformity of the wither by determining the output of made tea on withered leaf. If withered leaf of constant moisture content is produced from day to day, as is desirable, then this percentage should be constant.

Uniformity of wither has been emphasised above. This, apart from the considerations just discussed, also demands careful attention to plucking so that the green leaf may be as uniform as possible. Tipping leaf should if possible be treated separately.

The principal aim of withering is to reduce the turgid leaf to a flaccid condition suitable for rolling. Physical changes also take place whereby the leaf cells become permeable to the juices. At the same time chemical changes also occur but the nature of these is at present but imperfectly known. In the absence of more precise knowledge it must suffice to say here that there is every reason to believe that the normal withering period of 16-20 hours, which is common practice in Ceylon, permits of these changes taking place in a satisfactory manner. Teas made from unwithered leaf possess no character but there is yet little reliable evidence as to the limiting periods for withering. The conditions under which withering occurs, particularly the temperature, and probably the nature of the leaf, will influence the period in which optimum results will be obtained. Unduly long withers at high temperatures are, however, generally detrimental and may in extreme cases lead to souring of the leaf.

Withered leaf has naturally a higher sap concentration than the fresh leaf and this concentration has some effect on the rate of

fermentation. It is, in fact, possible to control the rate of fermentation within certain limits by variation of the wither, a soft wither giving a slower fermentation. This could be utilised in the low-country where there is a tendency, owing to the high temperatures, for fermentation to proceed too quickly.

While it is impossible to prescribe a wither suitable to all factories, we can say roughly that the figure for the out-turn of made tea on withered leaf need not be lower than 40% for a low-country nor higher than 50% for an up-country factory.

## ROLLING AND FERMENTATION.

The aim of rolling is to to bruise the leaf and mix the cell constituents which on exposure to air undergo a specific chemical change. These changes are responsible for most of the characteristics of black tea. The leaf cells having been rendered permeable during withering, the juices are readily expressed during rolling. At the same time shearing occurs and the leaf becomes broken up and twisted. Excessive shearing is detrimental, it is not conducive to appearance and less juice is expressed by this action than by a good twist which results in rupture of a greater number of cells.

The breaking of the leaf, as also its twist, is controlled by the physical condition of the leaf, by the type of the roller and battens, the speed of rolling and the pressure employed. The extent of sweep of the leaf box has also to be considered. Generally speaking, sharp-edged battens, high pressures, fast rolling and double or triple action rollers tend to cut the leaf excessively. In the earlier rolls twist should be of primary consideration as the leaf juices are thereby better expressed; cutting, however, is required in the latter rolls to deal with the fibrous stalk.

The application of pressure must be adjusted according to the wither. If heavy pressure be applied to soft withered leaf, the leaf yields to the pressure and takes little twist nor is it properly broken up. Light pressure should, therefore, be used as a rule with soft withered leaf, heavier pressures being possible with hard withered leaf. In any case the application of pressure should be graded, otherwise the leaf is broken up in an irregular way.

It is very general to roll in the initial stages without pressure on the ground that the application of pressure is liable to discolour the tips. Although this appears to be true when the pressure is excessive, under light or "quarter" pressure it rarely happens. Moreover, the so-called loss of "tip" is more often apparent than real. Under pressure a large dhool is obtained and the tip may, therefore, not show up so prominently as it would if the dhool were smaller. Pressure, however, is by no means the only factor determining the

size of the dhool. I have seen first dhools amounting to 25% in one case and only 3% in another, the rolling in each case being conducted with the "cap just touching". In the former the roller was a triple action machine with sharp battens, in the latter a plain table was used. The tips in the first instance were broken though no pressure had been employed.

Actually greying and discolouration of the tip would appear to occur more frequently during withering than during rolling.

The application of pressure when hard withers are employed, is not merely optional, but, in my opinion, a distinct necessity in order to squeeze out the sap. When a sample of the fired tea from the first dhool is infused, a thin liquor without quality or strength is obtained whenever the rolling has been conducted without the application of pressure. But when rolling has been carried out under pressure, the first dhool gives liquors having both body and strength. In the usual method of brewing the tea it is the soluble matter from the superficial layers of the leaf that is extracted, and when liquors with body and strength are required it should be the aim of rolling to press out the leaf juices and bathe the twisted leaf in it. As has been said elsewhere pressures cannot be applied on "soft withered" leaf and therefore hard withers and pressure rolling are conducive to strong liquors. The practice obtaining in some factories, of separating the dhools and putting these back again into the rollers—a practice which is believed to give strong liquoring teas—finds its origin in the realisation that a thorough crushing of the cells and smearing of the sap on the surface of the leaf is a factor which ensures strength. This practice is not always advisable, as such leaf is exposed to the high temperature in the roller a second time, and also the chances of staining the tip are great. Just as good results could be obtained by the application of pressure on the leaf during the rolling without the disadvantages of prolonged exposure to higher temperature or loss of tip. This loss of tip is sometimes due to the fact that the small buds get enveloped in a larger leaf during rolling.

In this connection I might refer to rolling for appearance as distinct from rolling for liquors. Rolling without the application of extraneous pressure gives a good twist to the leaf, and this is greatly facilitated when the extent of the sweep of the rolling platform is large. The danger of breaking or discolouring the tips is a minimum and red stalk is not exposed. The appearance of the tea, is therefore, better than it would be under hard rolling. In the latter case, unless the leaf is well withered, the leaf is liable to be irregular and red stalk exposed. However, the tendency of the present day market, is to demand good liquoring teas.

Very little is known about the relative merits of the several types of battens in use. In the initial stages of rolling when twisting is primarily desired in order to wring out the leaf juices, (a greater number of cells are bruised as a result of twisting than by chopping) a rolling platform without any sharp-edged battens is preferable For the final rollings, however, the usual "economic" rollers are admirably suited in order to reduce the size of the stalk by cutting.

The question whether wooden or brass battens should be used is an unsettled point. It is frequently believed that wooden battens turn out teas giving brighter infusions. I have not been able to verify this.

Hard rolling has the same effect as fast rolling. Both give higher percentages of broken grades and tend to expose red stalks, which in extreme cases spoil the general appearance of the teas.

One of the main effects produced during rolling is rise of temperature. This is due to two causes. Firstly, chemical action and secondly, mechanical or frictional action. The intensity of the chemical action drops off with time and the mechanical action too, as the quantity of leaf for rolling gets reduced. Therefore, for equal pressure applied during the rolls, the production of temperature is greatest during the first rolling but steadily drops off with the number of rollings. The usual practice of rolling the leaf for the first 30 minutes without pressure but increasing the pressure for the later rolls, tends to equalise the temperature production during the whole of the rolling period.

The rise in temperature is relatively less important than the actual temperature obtaining within the roller, which to a large extent depends on the room temperature. Thus a rise of temperature of 20°F. in an up-country factory where the room temperature is 65°F may not be serious; but a similar rise in a low-country factory where the room temperature might be 80° is objectionable. As far as possible the temperature should not be allowed to rise beyond 86° and this should be considered a maximum limit. This may appear as a counsel of perfection in a low-country factory, but part of the soluble tannins are rendered insoluble at temperatures above 86°.

There are two ways of minimising the rise in temperature:—(1) cooling down the rolling room by an efficient humidifying device, the cooling effected in this way is considerable during the dry seasons; and (2) controlling the pressure application by repeatedly releasing pressure by raising the pressure cap, thus exposing the leaf to the cool atmosphere of the rolling room. When the pressure is released it may be advisable to break the balls of leaf formed during the rolling. The timing of the application and release of pressure should be adjusted according to the temperature produced.

The rise of temperature when the leaf is soft withered is generally less than the rise when hard withered leaf is being rolled, other conditions being equal.

Efficient roll breaking and sifting is of enormous value in cooling the leaf before the bulk is returned to the roller again. This process often receives very little attention. Particularly for low and mid country factories, not only should the cooling be complete but all chances of the small broken leaf entering the roller again should be avoided. In fact, it is often advantageous to conduct the sifting process twice, the bulk passing over the sifter being sifted a second time; the dhool then will not be uniform but it can be divided into two fractions, the usual dhool and the "Kambi". I have observed this fractionation in a few factories with splendid results. This deserves extended application in mid and low-country factories. The two fractions have to be fermented and dried separately, this will also prove advantageous in the final grading of the teas.

It has already been said that all precautions should be taken to see that the temperature in the rollers is not excessive. Fermentation takes place at an accelerated rate at high temperatures, provided such temperatures are not very high as in the driers, when it will be arrested. If rolling could be conducted without exposing the leaf to high temperatures, as for instance by the use of cooled rollers, it would certainly be an advantage. Extended rolling can normally only result in heating the leaf for protracted periods in the rollers. The effects of rise in temperature are not seriously felt when the rolling room is cool, say 60° or 70°, but such effects are seriously felt in mid and low-country factories where the rolling room temperatures are high. The number of rolls should, therefore, be reduced to a minimum in such cases. Long periods of rolling are popular because these result in a large percentage of broken grades. Further, some planters believe in breaking the leaf as far as possible in the rollers, preferring this to cutting the leaf in the cutters after drying. It is my opinion that both these considerations have been carried too far.

One of the principal, but often ignored, benefits of humidification, lies in the cooling effected thereby. This is perhaps of comparatively greater benefit for a low-country factory than the humidification itself. When humidification is conducted on right lines, without detriment to ventilation, the temperature of the room atmosphere cools down to within a degree of the wet bulb temperature. The latter is usually low when the atmosphere is "dry", and considerable cooling is thereby effected. On the other hand, if ventilation is poor, the wet bulb temperature inside the room rises and stands at a higher level than the corresponding outside temperature and, in extreme cases, it may be just a degree or two below the

dry bulb temperature. It is, therefore, necessary to check the room temperature against the outside, to ascertain whether or not the humidification is conducted on right lines.

Many factories are not provided with the modern systems of humidification. The usual practice is to hang hessian or coir curtains against the room windows, these being maintained wet by a current of cold water. In some cases the effects are satisfactory. The curtains should be hung against the windward side of the room. This statement may appear unnecessary but, unfortunately, I have known several cases where this is not done. The wet curtain arrangement gives reasonably satisfactory results when the blowing of the wind from outside is neither excessive nor too slight. When the blowing is excessive the surface of the fermenting leaf blackens and this results in dull and mixed infusions. This excessive draught may be obviated to a certain extent by the use of double curtains, both maintained wet. When the movement of air outside is slight, air can be drawn in by creating a mild suction in the room by artificial means, such for instance as by fixing up fan blades to the shaftings. I have seen this done in a factory with very good results.

Humidification prevents the loss of moisture from the surface of the fermenting leaf and consequent drying. Dried leaf hardly ferments at all. Stirring the leaf results in the exposure of fresh surfaces to the drying action and should be avoided. Teas fermented under non-humid conditions, with consequent surface drying, give dull infusions.

Any system of humidification resulting in a settlement of water on the surface of the fermenting leaf is faulty. Under this category come the various methods of spraying.

One of the methods employed for preventing surface drying, during the fermentation of the leaf is spraying the leaf with water, or even in rare instances a dilute solution of potassium permanganate. The treatment is repeated at intervals to make sure that drying does not occur. Soft withers are also taken during the dry weather and this is believed to overcome the surface drying. None of these practices appear to be sound. All these involve removal of additional quantities of water during the drying process, thus putting a strain on the drying machinery. When the addition of water is excessive, and this is not rare, fermentation is interfered with, and as all the portions of the fermenting leaf, in the ordinary course of things, are not wetted uniformly, unequal dilution of the leaf juices takes place, thus interfering with the uniformity of fermentation. The use of potassium permanganate is strongly deprecated. It is a powerful oxidising agent and oxidises the tea tannins,

Surface drying is less with a hard-rolled leaf than with a light-rolled leaf, as the former is well smeared with a layer of leaf juices which is not the case with a light-rolled leaf.

It should be remembered that the prevention of surface drying is not the only benefit of adequate humidification. Reference has already been made to the cooling and ventilation.

The rolling and fermenting rooms should be airy, and maintained scrupulously clean. The leaf should be handled as little as possible during the rolling, roll-breaking, or fermentation.

Fermentation is best carried out on cement floors. Experience shows that it is far easier to keep the floor clean than fermenting racks. In the majority of cases where racks are used, old leaf, sometimes putrefying or covered with mouldy growths, accumulates in the crevices or corners and often these are not accessible to scrubbing brushes. The floor, moreover, is usually a degree or two cooler than the room temperature. A comparison of the teas fermented on glass, asbestos, lead, wood and cement surfaces, showed that cement gives the best results.

Leaf should not be spread thickly on the fermenting platform. One of the means adopted to prevent surface drying is to spread the leaf thick. A thick spreading encourages a rise of temperature in the body of the fermenting leaf, and at the same time restricts the access of air to a large portion of the leaf. Fermenting leaf absorbs oxygen and gives out carbon dioxide, it should, therefore, have free access to fresh air. This is one reason why the question of adequate ventilation of the fermenting room is so important. A maximum rise of temperature of 7° was observed in the course of an experiment conducted at St. Coombs when the leaf was spread 3 inches thick and 4° when the thickness was reduced to $2\frac{1}{4}$ inches. No rise was detected when the thickness was $\frac{3}{4}$ inch, and it was only 1° when the leaf was spread to the more usual $1\frac{1}{2}$ inches thickness. The temperatures were recorded about half-an-hour after the leaf was spread on the fermenting floor, and kept steady for about 4 hours during which the readings were taken. In the first case the teas were reported on by tasters as giving dull infusions and disappointing liquors. With a $\frac{3}{4}$ inch spread surface drying was evident and the $1\frac{1}{2}$ inch spread gave the best result.

It is generally observed that later dhools ferment more quickly than the earlier ones, and, therefore, in an attempt to ensure a more or less similar degree of fermentation, the dhools will have to be fired in the reverse order, instead of the more usual regular sequence. If we assume 30 minutes' rolling periods, it is clear that the first dhool, which remained in the roller for the first 30 minutes, will have

fermented at the higher temperature obtaining in the roller for 30 minutes only. The second dhool will be in the roller for 1 hour, the 3rd for $1\frac{1}{2}$ hours and so on. Fermentation is more rapid at the higher temperature within the rollers than on the fermenting platforms, and, therefore, the fermentation of the 3rd dhool when it comes out of the roll breaker will have proceeded to a much greater extent than that of the first dhool. The argument, however, cannot be carried too far, for there is a varying amount of leaf juices squeezed out roll after roll, and as the leaf gets depleted of juices the fermentation slows down. Further it would not be possible to wait until all the dhools are ready before starting firing, for then most of the dhools would have become over-fermented. Generally speaking, where pungent brisk liquors are required, the fourth and subsequent dhools should be fired soon after roll-breaking and the earlier dhools as soon as possible after the fourth. If the room temperature is high, even the third dhool should not be allowed to lie on the fermenting tables, but fired soon after roll-breaking. Longer fermentation may be necessary if coloury teas are required.

Fermentation is followed by diminution in pungency and increase in colour. Long fermentation results in loss of briskness and the liquors become dark and dull. The infusions too become dull. The degree of fermentation to be aimed at depends on the type of tea required. Nosing is a reliable index of fermentation.

Scrupulous cleanliness must be maintained in the rolling and fermenting rooms. After the day's work all the machinery and the floor should be thoroughly washed with water, and proper care should be taken to see that no leaf remains in the corners of the roll-breakers, the crevices in the fermenting racks or the battens of the roller, etc. Once a week or fortnight a thorough wash with a dilute solution of potassium permanganate should be given. Whenever this is done it is necessary to finish off the cleaning with a liberal supply of water. The use of washing soda or soap is deprecated. Where trolleys are used for receiving the rolled leaf from the rollers, these should be thoroughly cleaned after the close of the day's manufacture. It is very unfortunate that these troughs rarely receive attention. If hessian is used for receiving the leaf from the rollers this requires a periodical washing. All oil stains should be removed.

## FIRING.

The two principal consequences of firing are the checking, or, as it is more usually called, "fixing" of the fermentation and the reduction of the moisture content of the leaf so as to ensure its keeping qualities.

Sun-drying, practised at some seasons of the year in a few places, results in a black tea which on brewing is liable to give a liquor with a metallic taste. The product fired in the usual way is free from such a taste. Further a sun-dried tea does not appear to keep well although, when fresh, it possesses more flavour than the tea fired in the usual way.

Fermentation is arrested when the leaf is subjected to a temperature of 150°F, but a much lower temperature is sufficient when the leaf is subjected to a blast of air. It appears that a temperature of 120°F is quite sufficient to arrest fermentation under such conditions.

The usual practice is to expose the leaf to a fairly low initial temperature in a blast of air and then to gradually increasing temperatures. It is clear that the initial exposure should be enough to arrest fermentation, or about 120°F. Loss of water also takes place at this stage. This loss is from the surface and is made good by the transference of water from the core. To ensure uniform drying, therefore, the rate of loss of water from the surface should equal the rate of transference from the centre to the surface. If the former is too rapid, as happens when the leaf comes into contact with a blast of unduly hot, dry air, the surface dries up and becomes hardened. This phenomenon is usually referred to as "case hardening." The moisture from the core cannot escape, as the surface has become hard and offers a high resistance, unless the leaf is subjected to a very high temperature, enough to cause a high internal pressure of the water vapour enabling this to overcome the resistance of the hard shell and escape. When this happens tiny blisters appear and are noticeable with some "high fired" teas. This is known as blistering.

If the leaf is initially exposed to too low a temperature, fermentation is not arrested, but continues in the drier in an atmosphere of warm humid air, and "stewing" results.

It is, therefore, clear that the fermented leaf in the *initial* stages should be surrounded with air at a temperature high enough to arrest fermentation, but not so high as to cause "case hardening". Experience shows that this is achieved when the temperature is about 120°F. Loss of moisture from the leaf should be gradual and uniform, and the tea coming out of the drier should contain 3-4 per cent moisture.

Experiments carried out in India and Japan have shown that exposure of leaf to a high temperature is detrimental to the tea and the optimum temperature for firing has been shown to be about 176°F. Higher temperatures spoil both flavour and colour, the soluble substances and tannin decreasing remarkably. According to

Carpenter and Harler high firing results in loss of briskness and strength, and the tips may be destroyed. Teas fired below 140° do not keep.

A proper gradient of temperature and humidity is established when the machine temperature is about 180°-200°, and the exhaust temperature 110°-120°. Under these conditions briskness is maintained and the loss of tannin bodies is a minimum. An exhaust temperature above 120° indicates that firing is not being carried out on economical lines as that only means loss of utilisable heat.

"Case Hardening" appears to be more common than "stewing". The working temperature is often maintained high in order to obtain "brisk" teas and the leaf is spread very thinly on the trays; this is carried too far. A case hardened tea has very poor keeping qualities. The moisture from within the leaf gradually diffuses to the surface and the teas lose their crispness, and appear to all intents and purposes as "underfired" teas. It frequently happens that the machine temperatures are raised in order to overcome this supposed "underfiring", and case hadening becomes worse. By lowering the working temperature, and ensuring correct exhaust temperatures. this case hardening can be avoided.

Fermentation continues in a case hardened tea. I have already mentioned that the moisture content of such teas are high unless they are blistered. When the outer shell has become hard, the inner wet core appears to keep comparatively cool and the enzymes responsible for fermentation are not inactivated. During the period of storage, the fermentation continues and the tea lose briskness and pungency. The infusions as well as liquors become dull.

There are four ways of ensuring the correct exhaust temperature. The first and most obvious way is to raise or lower the machine temperature. This can be done only within limits, as has already been mentioned. The load on the trays can be altered. Cooling is effected by increasing the load as the quantity of leaf in relation to the quantity of air increases and *vice versa*. The third method is to alter the fan speed and increase or decrease the quantity of air drawn through, and lastly the speed of movement of the trays can be altered. Slower movements tend to raise the exhaust temperature.

Even firing is essential to secure a homogeneous product. This is obtained by maintaining an even distribution of the air within the drier. I have examined several driers where this is not the case. More usually the hot air is thrust into the forepart of the drying machine and the temperature in the back portion is very much lower. I have found differences as high as 20° between the front and back portions of the tray which first comes into contact with the heated

air from the drier. This difference is to be attributed to constructive defects in the furnace. The distribution of the air becomes more uniform as the exhaust is approached. Most factories aim at maintaining a more or less uniform working temperature and this is also essential to ensure even firing.

Flavoury teas suffer considerably at high temperature. It should be remembered that the essential oil which is responsible for the flavour is volatile with steam and is therefore, lost on exposure to high temperatures.

Prolonged drying also renders some of the soluble constituents of the leaf insoluble.

Hard firing is desired by some blenders as the teas show more briskness. Briskness is however maintained if the exhaust temperature is about 120° and "stewing" is avoided .

There is another important aspect of firing which has not received much attention. The "stalky" dhools, by which I mean the 4th and 5th dhools, take a slightly longer time—about 2 or 3 minutes—to be properly fired than the more leafy grades. When all the dhools are fired in the same way it is found that the later dhools contain a higher percentage of water.

*Final Firing.*—From the work carried out in India it appears that teas containing 5-7 per cent moisture undergo a "post fermentation" which is responsible for a "mellowing" which leads to an improvement in the quality. If the moisture content is below 5 per cent, this process does not take place. Teas containing more than about 7 per cent moisture are liable to get mouldy and tainted. Therefore, final firing, unless the moisture content is above 7%, may be definitely harmful, (1) by arresting the post fermentation and (2) by reducing the quantity of saleable tea.

Final firing should be considered a necessary evil during some parts of the year when the teas are liable to contain more than 7% moisture. It is to be regretted that many factories practise final firing as a routine before packing.

Final firing, when necessary, should be carried out at temperatures not exceeding 180°-200°.

## PICKING, GRADING, AND STORAGE.

Fired teas usually contain 3-4 per cent moisture when they leave the drier but they absorb considerable quantities of moisture during the picking of red stalk and grading, particularly during the picking out process. This absorption is a minimum if the work is carried out in an atmosphere of 60-65% humidity. Below this teas lose moisture, and if the humidity is greater than 60-65% they gain

moisture. It is, therefore, necessary to carry out these processes in a room maintained at about 60-65 per cent humidity. This should not be difficult in most factories, as a current of warm dry air can be drawn into the room from the drier. Grading rooms should be equipped with hygrometers, properly maintained. The fluff makes the muslin dirty and therefore frequent renewal is necessary and a draught of warm dry air created whenever necessary. The room should be damp-proof.

The storage space should be adequate and the teas should not be allowed to lie about. The bins should have no leaks and should be fully exposed to the atmosphere of the drying room.

Grading depends upon the market requirements and does not come under the scope of the present article. However, the leaf should be handled as little as possible in order to prevent greying. The blackness of the tea is confined only to the superficial layers and when the teas rub against hard surfaces, this layer is rubbed off and teas become grey. It is better to reduce contact with metal as much as possible. Greying is assisted by fast or rotating movement of sifters and the teas should be subjected to as few cuttings as possible.

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## REVIEW OF THE WORK OF THE SCIENTIFIC STAFF—APRIL-SEPTEMBER.

The Mycologist was on vacation leave from the 22nd July, and Mr. Tubbs was in charge of the Section, in addition to his own duties, during Dr. Gadd's absence. Eighty-seven consignments of diseased plants were received for examination in the Mycological Section during the period under review and ten estates were visited.

As is usual during these months a large number of deaths occurred as a result of lightning. Deaths following lightning are frequently mistaken as the results of a root disease owing to the sudden demise of a number of bushes, followed later by the death of others on the perimeter as though the disease were spreading slowly. The effect of lightning on young Grevilleas interplanted with tea may be more extensive than in the tea itself. In one instance about 30 tea bushes in a patch were killed as a result of a lightning strike, the surrounding tea being unaffected. Its effect on young Grevilleas was noted to extend for a distance of about 100 yards from the struck patch. The Grevilleas near to the struck area died, those further away died back from the top as though affected by a stem die-back. The symptoms developed much later on the Grevilleas and the affected area continued to extend long after the effect on the tea had died out. As the centre of the area of affected Grevilleas coincided

with that of the affected tea and as there was definite evidence of a lightning strike at the centre, there could be no doubt that the deaths and die-back in Grevilleas would be difficult to diagnose.

An interesting case of a leaf disorder was met with where the whole epidermis above an apparently healthy palisade tissue had lifted up in the form of a blister over the whole leaf. No fungus could be found between the epidermis and the rest of the leaf. Portions were embedded for further examination.

The serious economic results which may follow ignorance of, or failure to, use the recommended methods of dealing with root diseases was strikingly shown by one of the estates visited, where, until shortly before the visit of the Acting Mycologist, Ustulina disease had been allowed to flourish unchecked. Of the total area, probably more than one-third consisted of vacancies where dead bushes had been removed and burnt shortly before the visit. The effect upon yield and cost of production can be easily realised and should illustrate the advisability of making use of the Institute's services as soon as deaths are found occurring in the tea.

Much time has been spent by Dr. Gadd in a thorough reorganisation of the Institute's Library and substantial progress has been made in the classification of the very large number of Journals, Bulletins and miscellaneous publications which the Library now contains.

In the Entomological Section the new insect breeding room was completed, and the breeding of grain moths to supply the tortrix parasite with eggs was restarted. A supply of *Ephestia Kuchniella* was received from England but neither this nor *Ephestia cautella* has proved very satisfactory. *Corcyra cephalonica*, on the other hand, seems very promising. Another species of *Trichogramma*, *T. minutum*, is shortly expected from the Farnham Royal Laboratory. This is a smaller species than the one at present available and has been used with much success in breeding work elsewhere.

Work on Nettle Grub has been intensified and additional accommodation secured at Passara which provides room for the laboratory and stores and quarters for the two field assistants who were appointed in May. An insectary was also constructed and a small meteorological station, the instruments for the latter being very kindly loaned by the Colombo Observatory.

A number of visits was paid by the Entomological Staff to estates reporting attacks of Nettle Grub. By the end of June the grubs were found to be parasitised in most localities. Wilt has also been fairly common. Reports have from time to time been received that lime dust, as also the Red Ant (*Oecophylla smaragdina*), are

effective against Nettle Grub. Trials of both have been made but with entirely negative results. So far, spraying with laundry soap and water (1 lb. to 40 gallons) is as effective as, and more economical than, anything else.

To obtain more accurate information regarding Nettle Grub attacks, printed postcards, to be filled in and returned monthly, were issued to 126 estates in Uva. Such returns should greatly assist in giving a good idea of the seasonal prevalence of the pest.

An experiment to determine the effect of burning grass land on the population of White Grub was undertaken and is reported elsewhere in this issue. The results showed that firing had no effect.

On the whole, during the period under review, particularly the last quarter, insect activity has not been very noticeable, no doubt due to the almost continuous rain and lack of sunshine in many districts.

The time of the Agricultural Chemist has been largely occupied with field experiments. The nitrogen-potash experiment is now in full plucking and the layout of the experimental area on the new clearing was completed. This experiment comprises six blocks of plots bounded by three types of drains (1) ordinary, (2) bunded, and (3) reverse slope. Of the thirty-six plots involved, eighteen were burned before forking and the rest plain forked and the patna grass turned in. The whole area has been surveyed in detail, and measurements of the total precipitation, run off, and absorption will now be commenced. The data collected will not only show the efficiency of the various types of drain, but also the relative differences between the behaviour of burned and unburned land.

This experiment represents the initial step in the Institute's soil erosion programme.

The analyses of the artificial bulk manure have been proceeded with. The nitrogen content shows an approach to a maximum figure at the end of three months, after which a steady decline in nitrogen content in the uncovered heap is noticeable. The maximum nitrogen content was 1·72%, which represents a recovery of nitrogen from the vegetable material and added reagent of over 90%. These results demonstrate the practicability of obtaining a satisfactory compost under the conditions of manufacture adopted, i.e., the semi-pit method described in the Annual Report for 1930.

There has been a marked increase in advisory enquiries, a very large portion of these relating to systems of artificial and green manuring.

A non-technical account of the work on Experimental Errors with Tea, based on the Scrubs Uniformity Trial, has been published as Bulletin No. 6 of the Institute.

The Plant Physiologist has continued his work on the growth of seedlings from shelled and unshelled seed; nitrogen analyses have been made and the data examined in conjunction with the growth figures. The provision of an abundant nitrogen supply for seedlings appears of importance.

In connection with work on the propagation of tea a test of the effectiveness of various types of etiolation was started in August. 1930. Three treatments were tried:—

(a) bushes cut back to 8 inches and completely buried.

(b) bushes cut back to 8 inches, allowed to shoot and then buried to the tips of the shoots.

(c) bushes stripped of leaves and non-woody stems, and completely buried.

On examination in May, treatment (a) had prevented growth of new shoots, except in a few cases. Treatment (b) had resulted in the production of healthy stems half-an-inch thick and bearing numerous laterals above the ground; while treatment (c) had prevented growth except where tips of the shoots had been exposed by erosion. Of the shoots produced below ground level from the three bushes in series (b), thirteen of the total of twenty-two bore roots.

The further results obtained with these rooted branches were disappointing, however, as only about 8% grew.

Using small wood cuttings, about 4·6% show new leaves. No growth has been obtained from cuttings made from large wood. Fresh attempts are being made at rooting branches by ringing the stump below their point of origin before burying.

A pruning experiment designed to investigate the influence of time and type of pruning has been started at St. Coombs on an area of $4\frac{1}{4}$ acres. Three types of pruning, e.g., a clean prune, a cut across, and a rim lung pruning are being tested out with three different times of pruning, August, December and April. The experiment will be repeated, so far as the types of pruning are concerned, at Peradeniya and Galatura Estate in order that the influence of elevation may be examined.

As previously mentioned Mr. Tubbs was in charge of the Mycological Section from the 22nd July until Dr. Gadd's return.

Dr. Evans being on home leave, Mr. Sastri has been in sub-charge of the Biochemical Division.

A good deal of time has been spent in bringing the small scale experimental machinery, installed in the Factory in February, into proper working order, and comparing this plant with the normal factory machinery. While, generally speaking, the performance of the small machines has been satisfactory, and the teas turned out have been favourably reported upon by brokers, certain differences, have come to light, e.g., difference in twist and the particle size of the dhools of the rolled leaf, due to the small extent of the sweep of the box over the rolling table, absence of heating during the rolling owing to the small capacity of the rollers, and the temperature gradient in the drier. These show the need for verifying the results obtained with the small-scale machinery on the usual factory scale.

Teas that have been stored in different containers and different conditions of moisture have been compared as regards their keeping qualities. Analysis shows that teas which have been stored dry in a desiccator tends to lose a part of the soluble matter, and there is a definite though small decrease in the tannin content as a result of ageing. Teas stored in wooden boxes, with or without lead lining, have deteriorated considerably during the six months the experiments have been in progress and have become very flat and soft. According to the report of the tasters, though all the teas have lost their original characteristics, those preserved in stoppered glass bottles and under vacuum have deteriorated to a less extent than the others.

Experiments to determine the extent to which the teas absorb moisture during picking, grading, storage before packing, and bulking are being carried out. It has been observed that greater absorption takes place during picking than in any other treatment. The humidity of the air in the grading room is the controlling factor and data bearing on this are being collected. It is advantageous to carry out the bulking process, prior to packing, in the drying room, as under these conditions the teas do not seem to absorb any moisture.

The condition of the market during most of the year and the consequent necessity for greater care in manufacture has resulted in numerous enquiries being received for advice in regard to various aspects of manufacture. Much of Mr. Sastri's time has, therefore, been spent in visits to a large number of factories. Trouble in regard to firing has, perhaps, been the most common complaint, but during the course of these inspections various other defects of common occurrence have come to light. An article dealing with some of these points will be found elsewhere in this issue.

ROLAND V. NORRIS.

# MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON.

A meeting of the Board of the Tea Research Institute of Ceylon was held at the Ceylon Chamber of Commerce, Colombo, on Friday, July 24th, 1931.

*Present*:—Mr. R. G. Coombe (Chairman), the Hon. the Financial Secretary, the Hon. Mr. D. S. Senanayeke, the Hon. Mr. T. B. Panabokke, Mr. A. G. Baynham, Mr. R. D. Morrison, Major J. W. Oldfield, Major H. Scoble Nicholson, Messrs. J. D. Finch Noyes, Jas. Forbes (Jnr.), Gordon Pyper, A. W. L. Turner (Secretary), R. R. Muras (Assistant Secretary), and by invitation Dr. Roland V. Norris (Director, Tea Research Institute of Ceylon).

Before proceeding with the business of the meeting, the Chairman congratulated the Hon. Mr. D. S. Senanayeke and the Hon. Mr. T. B. Panabokke on being elected to the Ministries of Agriculture and Lands, and of Health, respectively, as well as Major J. W. Oldfield on his nomination to the new Council.

He also welcomed Mr. R. D. Morrison, Acting Chairman, Ceylon Estates Proprietary Association, and Mr. Gordon Pyper, who had been temporarily elected to the Board, *vice* Mr. G. K. Stewart and Mr. John Horsfall.

*Estimates of Income and Expenditure for the period 1st July to December 31st, 1931.*—The Chairman announced that the Finance Sub-Committee after carefully considering the financial position had recommended that the question of additional bungalows should be re-considered in three months' time and that in the meantime nothing should be done.

Major Oldfield proposed that the recommendations of the Finance Sub-Committee should be accepted, and that the whole question be reconsidered in three months.

This was seconded by Major Scoble Nicholson and unanimously agreed to.

## VISITING AGENT'S REPORT.

The Chairman referring to the report dated the 21st April, 1931, which had been sent to all members, reported that more than 50 per cent of the work on the new clearing had, he was informed, been completed and the whole should be completed by the end of July. The four acres experimental block was finished on July 23rd.

The additional tea stumps required had been obtained.

The question of shade trees and wind belts has been satisfactorily arranged.

## NETTLE GRUB.

*Field Assistants.*—Reported the appointment of Mr. W. T. Fonseka as first field assistant to Mr. Austin. The appointment to date from May 25th, 1931.

Reported the appointment of Mr. K. H. M. Goonatillake, as second field assistant also to Mr. Austin. The appointment, which is at present a temporary one to date from May 7th, 1931.

## 18TH REPORT (TEA) OF THE IMPERIAL ECONOMIC COMMITTEE.

The Board unanimously decided that it was opposed to the suggestion of establishing Government tea seed gardens in Ceylon on the lines proposed by the Economic Committee.

The Chairman added that the Planters' Association of Ceylon and the Ceylon Estates Proprietary Association also, he understood, held the same views.

## EXPERIMENTAL PROGRAMME.

The Director reported that arrangements had been made to start pruning experiments at St. Coombs next month and at Peradeniya and Galatura Estate (Ratnapura District) in April, 1932.

With regard to the Galatura experiment, the Board endorsed the vote of thanks passed at the meeting of the Experimental Sub-Committee and instructed the Secretary to write to Messrs. James Finlay and Co., Ltd., conveying the Board's thanks and appreciation to the Directors of the Amalgamated Tea Estates Company, Limited, for the facilities afforded to the Tea Research Institute.

Mr. T. B. Panabokke expressed a wish that small-holders should be advised of experiments, which are to be carried out at Peradeniya. The Chairman undertook with the assistance of the Department of Agriculture to endeavour to give effect to this wish.

## TERMITES.

Reported that owing to the unsettled conditions in India, Dr. Snyder's visit has been cancelled.

## SENIOR SCIENTIFIC STAFF.

*Renewal of Mr. Eden's Agreement.*—It was resolved unanimously to renew Mr. Eden's agreement on the present terms for a further period of five years as from October 18th, 1932.

*Superintendent's Agreement.*—The Chairman announced that this agreement was duly signed and sealed on July 8th, 1931.

## JUNIOR SCIENTIFIC STAFF.

Reported the appointed of Mr. Koch, who will take up duties as from the 1st September.—Confirmed.

*Future Appointments—Field Assistants.*—The Director suggested that these assistants should be on a scale of Rs. 1,080-75-1,380. One man was immediately required for St. Coombs and could temporarily occupy the Superintendent's old quarters near the factory. This was agreed to.

## SMALL-HOLDERS.

The Chairman said that the Sub-Committee consisting of Mr. T. B. Panabokke, Mr. D. S. Senanayeke, the Director of Agriculture, the Director, T. R. I. and the Secretary had so far been unable to meet.

Mr. T. B. Panabokke undertook to call a meeting in Colombo at an early date.

## PUBLICATIONS.

(a) The Board agreed that from 1st January, 1932, 25 cts. should be added to the amount of subscription for those resident in India, to cover commission due on Indian cheques.

## SALE OF PUBLICATIONS.

(b) The Chairman read the following figures:—

| | | 1930 | 1931 |
|---|---|---|---|
| India | ... | 58 | 115 |
| Outside Ceylon and India | ... | 31 | 33 |
| Ceylon | ... | 9 | 9 |
| Publications issued free | ... | 1,266 | 1,287 |

A. W. L. TURNER,
*Secretary.*

# MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE, OF CEYLON.

A meeting of the Board of the Tea Research Institute of Ceylon was held in the Victoria Commemoration Buildings, Kandy, at 10-30 a.m. on Friday, the 23rd October, 1931.

*Present.*—Mr. R. G. Coombe (Chairman), the Director of Agriculture, the Hon'ble Mr. T. B. Panabokke, Messrs. A. G. Baynham, C. E. Hawes, J. W. Oldfield, H. Scoble Nicholson, J. D. Finch Noyes, John Horsfall, Jas. Forbes (Jnr.), A. W. L. Turner (Secretary), R. R. Muras (Asst. Secretary), and by invitation Dr. Roland V. Norris (Director, T.R.I.), and Mr. J. W. Ferguson (Visiting Agent).

*Absent.*—The Hon'ble the Financial Secretary and the Hon'ble Mr. D. S. Senanayeke.

1. Notice calling the Meeting was read.

2. Minutes of a Meeting of the Board of the Tea Research Institute of Ceylon, held on the 24th July, 1931, were confirmed.

*Meetings.*—The Chairman said that he had received a letter from the Director of the Institute suggesting that one Board Meeting each year should be held at St. Coombs.

He proposed that their April Meeting be held at St. Coombs.

The Board agreed to this suggestion.

3. *Members of the Board.*—The Chairman welcomed back Mr. John Horsfall, who had returned from leave, and thanked Mr. Gordon Pyper for acting during his absence.

## 4.—FINANCE.

(a) *Statement of Accounts as at 30th September, 1931*, a copy of which had been sent to each member of the Board was adopted without comment.

(b) *Estimates for the year 1932 with the Finance Sub-Committee's recommendations thereon.*—The Chairman said that these Estimates had received more than ordinary scrutiny by the Finance Sub-Committee.

After the Estimates had been considered, Major Oldfield proposed and Major Nicholson seconded that the Estimates for 1932 be adopted.

This was unanimously carried.

It was also decided that Messrs. Hemachandra's tender for the bungalows be accepted.

## 5.—ST. COOMBS.

The Chairman announced that the Visiting Agent's Report had been sent to all members of the Board under cover of Circular No. A.2323/31, dated the 25th August.

## 6.—SENIOR SCIENTIFIC STAFF.

*Leave—Mr. Eden and Dr. Evans.*—The Chairman said that the Director's proposals to grant to each of these officers two weeks' extra study leave had been circulated to the Board and accepted.

The Director explained that these proposals were made to meet the housing difficulty and not at the request of the Officers concerned. Actually each officer was spending much longer than the time in question on courses of study. Under the arrangements now sanctioned Mr. Eden's leave would commence from the 16th December and Dr. Evans would return to duty on the 21st December.

The Director proposed that during Mr. Eden's absence on leave Mr. C. A. de Silva should be placed in sub-charge of the Agricultural Section. Mr. Eden's field experiments would be under the general supervision of Mr. Tubbs. The Board approved of these proposals.

## 7.—JUNIOR STAFF.

(a) *Assistant Entomologist, (Mr. G. D. Austin).*—The Chairman announced that Mr. Austin had been taken on the Staff as from the 1st October.

(b) *Field Assistants.*—The Director said that Mr. Nicol had been appointed in August as sanctioned by the Board and provision had been made for a second field assistant in next year's Estimates.

## 8. SMALL-HOLDERS.

The Chairman reported that the Small-holders' Sub-Committee held a Meeting on the 27th August, and their deliberations had been circulated to each member of the Board.

Mr. Panabokke said that as a preliminary, he thought the Director should draw up an estimate as to how much it would cost to appoint officers, etc., to supervise this work. The estimated expenditure would give them an idea as to whether the Scheme was practical or not.

The Director said that he had not yet gone into the matter in detail. He would, however, try and get out some figures.

Mr. Panabokke pointed out that his idea was that some action should be taken without delay.

The Chairman informed him that to carry out all the recommendations which had been made by the Sub-Committee would entail considerable expenditure. He wished to emphasise that the Board was in sympathy with Mr. Panabokke's idea and if a Scheme could be presented which would not entail too much expenditure, the Board would, he felt, consider it sympathetically.

## 9.—MINUTES OF EXPERIMENTAL AND ESTATE SUB-COMMITTEE MEETING HELD ON 17-10-31.

The Chairman asked the Director to report on the various decisions arrived at the Meeting held on the 17th October.

The Director said that the Minutes of this Meeting had at present only been sent to members of the Experimental Sub-Committee and would be circulated to the Board in due course.

The Sub-Committee had recommended that $10\frac{1}{2}$ acres be opened in 1932.

The Sub-Committee also considered that a definite reserve of about 5 or 6 acres unopened land should be made. Otherwise if they went straight ahead and opened all their land now, it might happen that they would ultimately have no land for experimental purposes. They had therefore set aside a small block as a reserve for future purposes. Survey Section 82 had been selected for this purpose. $4\frac{1}{2}$ acres was also being reserved in Survey Section 86 for experimental work on different jâts and varieties of tea.

Another question was in connection with openings. They had been approached by one or two gentlemen with the suggestion that they should have a small area for demonstration on the contour system of planting. The question had been fully considered by the Committee and they decided that a small area should be planted on the contour system as a demonstration plot in due course.

*Cover crops.*—The present cover crops included ground covers and bush covers, but prior claim was being given to ground crops in preference to bush crops. The Committee decided that a definite area of $2\frac{1}{2}$ acres should be put down under cover crops. The details of what crops should be used had been left over.

Mr. Horsfall said that if any members could give detailed figures of cost of control of cover crops it would be most useful. He had already come across one case, which he had asked to be sent to the Director and if any Colombo members should obtain figures it would be most useful.

10. (a) *Tuition to Visitors from other Countries.*—The Chairman stated that as the Finance Meeting at St. Coombs had been such a long one, the Sub-Committee had been unable to carry out the Board's instructions, viz., to frame rules and regulations in this connection.

(b) *Advisory work on specimens sent to Ceylon from other Countries.*—The Director said that he had received several applications for advice from South India. Sometimes it happened that it was an application from some planter known to the Staff, when, as a matter of courtesy, the information was supplied. In other cases the applicants were referred to their appropriate research stations.

## 11.—PUBLICATIONS.

(a) *Russia.*—An application for the Publications of this Institute had been received from Soviet Russia through the Ceylon Association in London. It was the unanimous decision of the Board that the Publications should be sent.

(b) The Board agreed that the supply of Publications should be increased from 1,500 copies to 1,600 copies.

(c) *Advertisements in "The Tea Quarterly".*—The Chairman said that the Director had already communicated his ideas on the subject. He too, thought that they should reverse their original decision not to accept advertisements for *The Tea Quarterly.*

The Director's proposal was put to the Meeting and it was decided with one dissentient vote that advertisements should be accepted, but that these should not be interleaved with the reading matter.

The Meeting terminated with a vote of thanks to the Chair.

A. W. L. TURNER,
*Secretary.*

# NOTICES.

The Institute's Laboratories are situated at St. Coombs, Talawakelle, and all applications and enquiries should be addressed to the Director, Tea Research Institute, St. Coombs, Talawakelle.

Specimens and other consignments sent by rail should be forwarded to Talawakelle Station c/o. Messrs. Hemachandra & Co., Forwarding Agents.

*Visitors' Day.*—The first Wednesday in each month has been set aside as Visitors' Day at St. Coombs Estate, when it is hoped anyone interested will visit the Station.

Visitors at other times are welcome but the Staff may not be free to show them round. Such visitors, on arrival at the Factory, are requested to ask for the Teamaker.

St. Coombs Estate is reached by taking the turn-off opposite culvert marked 28/10 on the Nanuoya-Talawakelle main road. A signpost has been erected at the turn-off.

*Publications.*—Applications for the Institute's publications should be directed to the Secretary, at Victoria Commemoration Buildings, Kandy, and *not* to the Director's Office.

It has been decided that, beginning with the issue of February, 1932, advertisements will be accepted for insertion in *The Tea Quarterly*. Full particulars, with details of charges, can be obtained on application to the Director's Office, St. Coombs.

ROLAND V. NORRIS,
*Director.*

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Vol. III. Part 1. February, 1930.

THE

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OF THE

## TEA RESEARCH INSTITUTE

OF CEYLON.

Edited by

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*Department of Mycology.*

Mycologist ... C. H. Gadd, D.Sc. (Birm.)
Assistant ... C. A. Loos.

*Department of Agricultural Chemistry.*

Agricultural Chemist ... T. Eden, M.Sc. (Manc.), A.I.C.
Research Assistant ... C. A. de Silva, B.Sc. (Agric.), (Lond.), C.D.A. (Wye).
Assistant ... E. N. Perera.
Field Assistant ... M. Piyasena.

*Department of Biochemistry.*

Biochemist ... D. I. Evans, Ph.D. (Lond.), B.Sc. (Wales).
Research Assistant ... B. N. Sastri, M.Sc. (Bombay), A.I.I.Sc., A.I.C.
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*Department of Entomology.*

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Assistant ... D. J. William.

*Department of Plant Physiology.*

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ROLAND V. NORRIS, D.Sc., F.I.C.,

Director, Tea Research Institute.

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St. Coombs, Talawakelle.

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